THE LEHIGH QUARTERLY.

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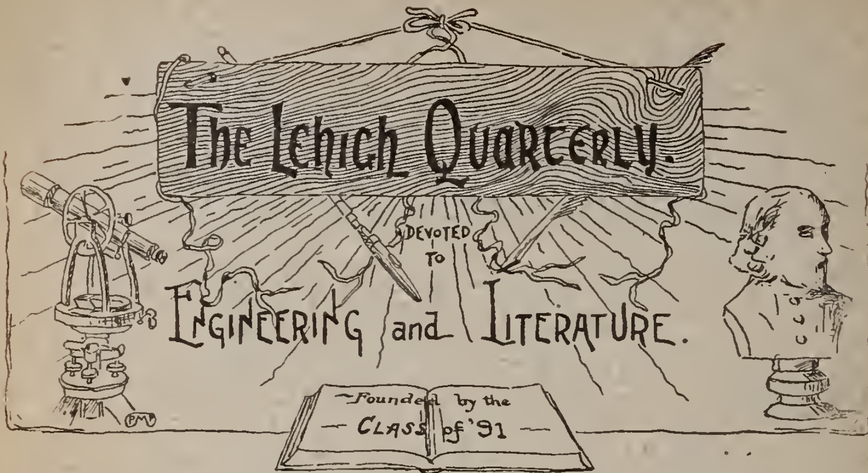

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THE

LEHIGH QUARTERLY.

FOUNDED BY THE CLASS OF 1891.

Vol. III. APRIL, 1893. No. 2.

THE TAU BETA PI SOCIETY.

The honorary society of Tau Beta Pi was established at this University in 1885, and its object is fully set forth in the preamble to its constitution, as follows:

"To mark in a fitting manner those who have conferred honor on their *Alma Mater* by a high grade of scholarship as undergraduates, or by their subsequent attainments as alumni, and to foster a spirit of liberal culture in the Technical and Scientific Schools of the United States."

It is the aim of the writer to discuss the considerations that led to its establishment, and its aims. Phi Beta Kappa is well known and, until quite recently, has been identified with colleges of the liberal arts. Even in its reorganized form, the drift is in favor of its old methods, and considerable feeling (unjust, perhaps) has been shown at the methods adopted by some chapters in the selection of candidates from mixed classical and technical applicants. With the rise of high grade colleges of a purely technical nature within the past quarter of a century, there has come the need for a technical Phi Beta Kappa, as the traditions of that ancient society are adverse to merit, if it comes outside of the "Humanities."

While some study for the delight of acquisition, and accumulate knowledge as a miser does money, the average man desires to possess the record of his abilities, provided that it can be

obtained in a fair and just manner; and he uses that record as a certificate when dealing with strangers who desire to know what manner of man he may be. College work ends in the presentation of a diploma, which signifies that all the work of a course leading to a certain degree has been passed in a satisfactory manner; but it does not explain the meaning of "satisfactory," nor show whether the scale be high or low. In a word, the old-fashioned diploma brings the valedictorian down to the level of the unfortunate, who has failed in every examination that he has met, and who graduates only after repeated reëxaminations, and gives no indication of their relative fitness to encounter the problems of practical life; for, in a technical course, the manner in which the work in college was performed will be a criterion of future aptitude or inability; while at best, the classical undergraduate work is a fit for something higher, and that higher work is to be the bread-winner. In a certain degree the list of commencement appointments meets the point noted; but only for the highest men in the class, and, at Lehigh, gives their relative rank for the last year and one-half before the final examination. To fully meet the case, and fully supply a fair and exact statement of the work done in this University, Tau Beta Pi was established, and so well has it met the demand that a graduate wrote to the writer on the subject, and stated that he valued his certificate in the society above the University diploma.

After some correspondence between high standing alumni, Tau Beta Pi was established in the Spring of 1885, and organized by the eligible men of the graduating class. In its formation, the first point decided upon was that high rank should not be the sole requirement in a candidate for membership; but he must be a man who can be lived with, as success in after life will depend as much on the adaptability of a man, as on what he knows. While, therefore, high rank will put a name on the list of candidates, it will not force its owner into a society against its best interests; and an elective requirement was introduced, so that all who have shown a lack of congeniality, or who have been visited by public reprimand or other penalties for dishonesty in university work, and have failed to exhonerate themselves, are passed by at the election. It is fitting to state that this privilege

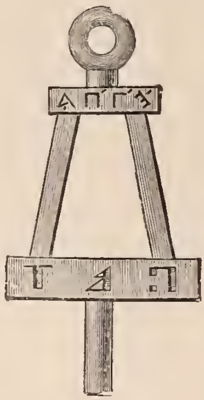
has been very seldom used, and tradition is against its use in the first case, and the high grade men who have been candidates have never been in the second class.

The next thing determined was, that it would never do to take a fixed number, or proportion from a class, without regard to the actual rank of the class. A minimum grade of seventy-five per cent. must therefore be surpassed by all candidates, and a class of generally low grade will have no members, or fail in its quota. There has been but one instance where the class failed to receive its full quota, and, in general, the limit could be placed at eighty per cent. Phi Beta Kappa used to take the first third in the class with an indifference to the actual rank, and its elections gradually fell into disrepute, so that some of the oldest chapters lay dormant for many years, and some are permanently dead. Tau Beta Pi selects only the first fourth of the total membership of a class as it appears in the *Register* at the beginning of the Junior year. Candidates for membership have, therefore, to contend with their classical rivals, and every classical in the first quarter means one less for Tau Beta Pi. Under the present conditions, the rivalry is wholesome, but there may arise in the future, a change in the relative numbers, or in the relative courses, that will compel an entire separation of technical from classical students. The graduating class this year will have both Valedictory and Salutatory given by wearers of the "Bent."

At first the elections were held at the beginning of the Senior year, that they might be based on the records of the whole of the first three years of the course; but, unless there were a number of post-graduates in college, it was very difficult to secure sufficient members to receive the new men and show them the work of the Society. It became necessary, therefore, to divide the quarter of the class into two parts: the first eighth being taken at the beginning of the second term of Junior year, on the basis of the records of two and one-half years. As the men enter the Society immediately, they become familiar with its workings before the graduation of the Senior Class, and are ready to receive the second eighth, whose rank can only be determined by the examinations at the end of Junior year, and also the Wilbur scholar of the year.

It is highly improbable that the men in this first eighth will fall below the first quarter of the class during the rest of their course; and hardly probable that those of the second eighth will do so; but it is necessary to establish a basis by which work can be done as undergraduates, and the one chosen was least objectionable.

The list of candidates is furnished to the Society by graduate members in the Faculty or Corps of Instructors who have no interest in the candidates. This list is, therefore, an impartial one, and the rank is carefully computed. There is, therefore, no room for favoritism or error, as the official records are consulted. The society holds a number of meetings each term, whose proceedings are secret, in that only members are allowed to be present, and the



current business is not mentioned outside. The work is chiefly the preparation of papers—generally scientific—which are read and discussed at the meetings. There is no restriction to any definite line of topics as yet, though plans are now forming for systematic research in certain directions.

The badge is the miniature bent of a trestle worn as a key, having on one side certain symbols known only to the initiated, and on the other the owner's name and chapter. Each member receives a certificate with his name printed therein, as well as the date of issue, which states the rank he has held in the class during his course, and the fact of his election to Tau Beta Pi as a consequent. The colors are brown and white, arranged in one-

eighth inch stripes alternating across an inch ribbon. From the first there has been an appreciation of the value of the Society, and a desire for membership therein. High stand alumni have written of their regret that it did not exist during their undergraduate life, and undergraduates look forward to securing the coveted rank that will show that they are not only good students, but have good "staying" qualities. It matters little, whether the diploma contains, or omits, the words "with honor," as the broad certificate of Tau Beta Pi is a "Magna cum laude" that supplies all omissions, and sends the fortunate owner into the world with his accurate rank. When the society is fully known to the workers of the world, the sight of the "Bent" will sufficiently answer the question as to the owner's faithfulness as a student.

The Lehigh chapter, having remained alone for some years, has reached its period of growth. During the last year a chapter has been established in the Engineering department of the Michigan State Agricultural College, where Mr. L. P. Breckenridge formerly instructor here, is now Professor of Mechanical Engineering. Several other chapters are in prospect, and it seems if Tau Beta Pi were about to extend into a wider field its capacities for usefulness and encouragement.

EDWARD H. WILLIAMS, JR.

RECENT DISCOVERIES OF PREHISTORIC REMAINS NEAR SCHAFFHAUSEN, SWITZERLAND.

TRANSLATED FROM THE GERMAN BY A. B. FICHTER.

The following is a translation from a report in a leading Swiss newspaper on excavations made by Dr. Nuesch, in Schaffhausen, Switzerland.

A publication by Prof. Dr. Oskar Fraas, the leader of cave investigators, and the likeness of the place described to one familiar to Dr. Nuesch, in the neighborhood of Schaffhausen, gave him the idea of looking for remains of prehistoric periods in that region. The rock he was specially reminded of by the illustration is called the "Schweitzerbild," and he communicated his idea, that at the foot of the rocks of the "Schweitzerbild" prehistoric remains could be found, to some of his friends and acquaintances; but a search of the place showed no signs of a cave along the overhanging cliffs, and the then prevalent notion, that objects of such ancient date could only be found either in very humid moss or in places sheltered from all atmospheric influences, such as caves, kept him from making excavations at that time. He attempted excavations one after another in caves of the Jura mountains, ever without success, and finally in 1891, after another fruitless attempt in the neighborhood, he tried his luck after all at the Schweitzerbild. The first bore at the west side of the cliff produced, down to a depth of 50 cm., nothing but ashes, but a ditch dug vertically against the middle of the rock unearthed, even at a depth of 30 cm., such a mass of modern and fossil bones and of crude flint, that a systematic excavation was at once undertaken.

On the spot called the Schweitzerbild, about two miles north of the city of Schaffhausen, are three cliffs rising out of a small plateau to a height of about 18 metres at the eastern end; the prehistoric remains were found at the base of the Western rock, which facing south-west, rises abruptly, overhangs in fact in some places by about 2½ metres. To the south-west the settlement is completely sheltered by the cliffs from the cold winds from the

north and the north-east. The solar rays are reflected from the mighty towering cliffs into the centre of the semi-elliptic space in front and warm the spot to such a degree, that the snow does not last long there in winter, and the heat in summer is well nigh unbearable. Not far away is a copious spring, which furnishes parts of the town of Schaffhausen with drinking water, and a little brook passes at a distance of about a hundred yards.

The excavations were made by removing strata of 20 cm. each; bones and *artefacts* (implements) found therein were carefully assorted and preserved. The place itself was divided into blocks of one metre square, and the situation and depth of each object when found was registered; nothing was thrown away, even if there were a thousand duplicates.

From the surface down the following layers were recognizable:

First, a layer of humus, 40 to 50 cm. deep; second, the neolithic stratum about 40 cm. deep; third, the upper Breccia stratum, at some places as deep as 80 cm.; fourth, the yellow paleolithic stratum, 30 cm. deep, which turns to black toward the edge; fifth, the lower Breccia stratum, or the layer of the rodentia, about 50 cm. deep; and sixth, the real diluvium.

At a distance of two metres from the rock the layers are the heaviest, and decrease in depth to the edge, until some of them disappear altogether.

In the humus layer were found glazed potsherds, besides pieces of glass, paleolithic flint knives and scrapers, together with bones and teeth of the pig, the boar, the elk, domestic cattle, horses and reindeer, all in motley confusion. These objects had been raised from the lower strata in digging graves recently. Iron nails, spear points and modern buttons are found here. The lower strata, however, are intact, and the objects are in their original positions.

The gray neolithic layer derives its color from the quantity of ashes that is evenly distributed over the whole place. In it was found a fragment of a ground stone axe, also stones partly ground, *artefacts* made out of bones or of antlers of the stag, unglazed and crudely fashioned potsherds, some of which were prettily decorated, antlers, partly carved, implements of flint and flint fragments, knives, scrapers, saws and drills, and

flint pieces half finished were quite frequent. Then again bone chisels, bodkins and needles made of bone, were found, giving testimony of the grade of culture attained by these people.

In this neolithic, as well as in the lower paleolithic stratum, all the marrowbones are found broken by the reindeer hunters, who evidently were very fond of that nourishing substance. According to Professor Th. Studer, of Berne, remains of the following species of animals were discernible in the gray neolithic stratum: elk, deer, boar, aurochs, diluvial horse, brown bear, mole, alpine hare, snow-hen. Very scarce, however, are the bones of the reindeer.

The remains of about twenty human individuals were also found in this neolithic stratum; many of these were children. Most of the children wore neck decorations made with rings of the tube-worm (Serpula), and had other funeral gifts; a careful burial of the children seems to have been customary. One child had been laid in a dry, walled grave, had a long chain of Serpula rings around the neck, and besides there were in the grave a red flint lance, broken at the point, large and small varicolored knives, a flint saw, a fine, stilletto like, very sharp little white knife, and a claw of some wild animal. Thus armed and prepared the child had started on the long journey into the hereafter. What a glimpse this affords into the emotional life of this generation.

Between this stratum and the lower yellow paleolithic, is a Breccia stratum, which near the eastern wall of the cliff is nearly 80 cm. deep, and consists mostly of uneven pieces of the weatherworn limestone cliff above. This stratum decreases with the distance from the rock, and at a certain distance disappears altogether, consequently the gray stratum there is followed immediatly by the lower yellow.

The Breccia stratum contains no ashes, no worked flint pieces, and no broken bones, a sign that the place had been uninhabited for quite a long time; yet there are found small bones and jaws of rodents, but only in small numbers.

Below the Breccia stratum is the yellow paleolithic, sometimes also reddish in color. In it no potsherds are found, no ground stones—only hammered ones—no bones or teeth of the boar,

the brown bear, the hare, the stag, or the deer; but, in large quantity, the bones and teeth of the reindeer and the alpine hare. Less frequently are found the bones and teeth of the diluvial horse, the ogre, the cave boar, the ice fox, the wolf, the aurochs, the capricorn, and of several species of fowls. Noticeably small is the number of bones of wild animals. Of the dog there is not a trace either in the gray or in the yellow strata. The bones in this stratum are still more broken up; they also break into pieces when taken out without showing signs of having been hammered. In comparison with the number of leg-bones and teeth of the reindeer, the number of bones from the vertebral column is very small. The reindeer hunters, perhaps, did not bring from their excursions after the reindeer anything but the parts that had much meat on, like the legs, and the head on account of the antlers; or, perhaps, the ribs and the vertebræ are more easily disintegrated. The first case is the more likely explanation, as other equally spongy bones are still extant and well preserved.

In the paleolithic stratum *artefacts* of bones, horn, and flint are more numerous than in the neolithic just above. A number of bone chisels, of which some possess very fine, sharp edges; beautifully worked bone arrow-heads and needles, with and without eyes, among them some extraordinarily fine ones with very small eyes; bones that have one or more holes drilled through them; reindeer whistles; perforated shells from the Tertiary basin at Maintz; oar, ammonites, and terebratula from the near Jura mountain; spongia from the Birmensdorfer strata; shark teeth from the diluvium at Benken and Lohn; a very great quantity of hammering stones from the adjacent moraine of the former Rhine-glacier; all these are found in this stratum. There are *artefacts* in large quantity made of flint, which the reindeer hunters found in profusion on the north-eastern slope of the Jura, and which they carried home; besides thousands of useless flint fragments and blocks, from which material for the tools was knocked off, knives, artistically worked, saws, large and small drills, among them regular circular drills, and single and double drills on one piece, arrowheads, and scrapers for the preparing of the skins are found. Of the drawings which were found, one is

especially worth mentioning by reason of its artistic execution. It is the fragment of a reindeer drawing, representing head, neck, forefeet, and breast of the reindeer. A fragment of a drawing was also found on another bone giving the hind feet of a reindeer, quite well recognizable. Specially interesting, however, are the drawings on a flat limestone 10 x 6 cm. On both sides of it drawings have been engraved with the help of a piece of flint. On the one side three animals are represented. In the upper center is a horse in a resting pose; the head is stretched out straight, somewhat raised and turned to the left, the two left legs cover the right legs, being in repose, making the right legs invisible. The horse has no mane, but a strong tail; all the lines are firm and deeply engraved. Then there is drawn a reindeer, the head held forward to the right, and in a jumping position; the extremely delicate forefeet are placed far apart. The antler partly covers the head of the other figure, and the beautiful small head, with the strongly indicated eye, reaches up to the neck of the horse. Underneath these two animals is the figure of a colt which has its fore and hind feet very near together; it holds the head anxiously up to the left side with ears pointed forward. The whole body tapers to the head so that the animal almost approaches the likeness of a kangaroo.

On the other side of the flat stone are also drawn several animal figures, over and into each other, very much like in the drawings found in caves of Southern France. Clearly definable are two horses with manes, and a half finished animal figure. Two heavy hind legs indicate a very large animal. Only by means of a cast or an enlarged photograph can this intricate drawing be fully deciphered. Several fireplaces were discovered in this stratum, among them a very elaborate hearth, which was started on the rodent stratum, and which contained even to this day several large pebbles—warming stones—in its several thousand years old ashes. Dr. Neusch succeeded, by extraordinary trouble and care, in removing this hearth undisturbed and intact. So beautiful a hearth had not yet been discovered in any reindeer settlement, either in France, Belgium or England. Besides a quantity of ashes, several pieces of wood were found with signs

of workmanship and perforations which had completely turned into brown coal.

The stratum immediately below this last one is noted for the many remains of rodents found in it; it is sharply defined from the above yellow stratum and contains only a few broken bones and *artefacts*. Prof. Dr. Nehring, of Berlin, distinguished in the material sent to him for investigation, several small rodents, moles, hamsters, mice and birds, besides some fish and the reindeer. These animals indicate largely a connection with the Fauna of the modern arctic and sub-arctic East Russia and West Siberia. At the time they dwelt near Schaffhausen the country must have been poor in forest, and the climate equal to that of the above mentioned regions. So far there have been found at this place remains of thirty-eight distinct animal species, while at another place (Kessler loch,) near it, only twenty-five species could be distinguished.

Immediately, in the year 1891, the results obtained here excited great interest in the scientific world, for the objects discovered are among the most important, both in quality and quantity, of the epoch of the West-European ice-period. The interest in the excavations has spread to wider circles during last year. German, French and Swiss societies have made them the subjects of their discussions. Dr. Nuesch lectured on the topic on August 3d, 1892, in the annual convention of the German Anthropological Society at Ulm, and on September 7th, in the Zoölogical Section of the General Assembly of the Swiss Society of Naturalists at Basel. The consequence was that the anthropologists and archaeologists of the different countries visited the place in vast numbers last summer. Prof. Boule of Paris, among others, visited the place for the French Government and stayed four days (Sept. 8–12,) in Schaffhausen for the purpose of studying the settlement thoroughly, and to be able to compare the reindeer hunters of Schaffhausen with those of France in reference to their culture, their customs and their habits. This scientist was specially pleased to note that here, as in the French settlements of that remote period, had been found drawings on bones, antlers and stones, as such drawings and carvings had been

known in France for upward of ten years, but had been so far put in question by German scientists.

Drawings of animals have not been found as yet either in German, Belgian or English caves, such as the reindeer hunters of France and Switzerland had executed with such accuracy and acuteness, that even today their skill must be admired, especially so since this art of drawing seems to have lost itself entirely among the lake dwellers and their posterity. The great dispute among the German and French scientists in questioning the genuineness of drawings of the reindeer-period—there have been about 300 found so far, if the geometrical figures are included—has been settled in favor of the latter by the newest discoveries near the Schweitzerbild. Yet, it still remains an open question in anthropology, how it is possible that a propensity and talent could be developed to such a degree as was the case with some reindeer hunters, and then again disappear without another trace.

The fact that a large number of human skeletons were brought to light in the neolithic stratum, as above mentioned, stimulated the interest in the excavations at Schaffhausen more especially. At the convention at Ulm, Professor Dr. Virchow only refused an invitation to inspect the spot, because he had to hasten to an international anthropological congress in Moscow. But on the 23d of September that eminent scientist appeared in Schaffhausen and viewed the discovered objects and the place of excavation most minutely; and what he saw on the twenty-seven tables in the exhibition hall in Schaffhausen, where all the *artefacts* and animal remains are arranged according to strata, as well as at the spot itself, excited his greatest attention. He even took part personally in the work of digging, for over an hour, and unearthed in the gray stratum, with his own hands, the skeleton of a child, which had also received a chain of Serpula rings at its burial. He expressed himself very flatteringly about the careful and circumspect management and arrangement of the excavation, as indeed there has been nothing neglected, which is needed to protect the place. It was fenced in and watched at night, the manager often sleeping there in person with the workmen in tents. Water barrels, sieves, and tables to dry the washed objects were right there and helped to expedite the work. Many ground plans

and profiles were taken and the most important objects were photographed in their places and original position.

On the side of the cliff the strata are vertically cut and are easily discernable to the visitor. Each of the strata was removed and sifted with the most scrupulous care; neither shovel nor pick was used to unearth the objects in the neolithic stratum, but they were loosened with specially prepared hooks or, mostly, with the hands only, then washed, cleaned, brushed, etc.

This settlement belongs to the epoch of the last ice period, as already hinted at—and more especially toward the end of that period. Dr. Nehring in Berlin, Prof. Studer in Berne, Prof. Heim in Zürich, Prof. Gutzwiller in Basel, and Prof. Boule in Paris, all agree on that point, and judge of the time by the Fauna, by the remains of the animals and the erratic stones, which the reindeer hunters must have fetched from the moraine of the Rhine glacier near by. Consequently the region around Schaffhausen must have had a similar climate to that of Eastern Russia and Western Siberia at the present time. The place was especially adapted for a human settlement. It is situated on a plateau, between two long and very considerable valleys, toward each of which it is depressed. On the north are picturesque mountains which protect it from the rough north and east winds. The settlement is not in a cave but entirely open, at the foot of the cliffs; it covers an area of about 500 square metres, of which 300 square metres have been excavated. The height above the level of the sea is 470 metres, whereas the Rhine at the bridge at Schaffhausen is 392 metres above the sea.

The small plateau has beautiful green meadows in summer and the surrounding mountains are covered with a fine forest. The whole is a real idyl, a charming, agreeable spot, which pleases the eye, and the name "Schweitzerbild," which the people have given it, fits it to perfection, since it is a miniature of Swiss scenery. It is plausible, that the people living during that remote ice period found an adequate refuge here. The whole of Switzerland and probably the heights of the Black Forest were still covered with glaciers, as well as the low valleys of Merishausen and Herblingen. The fall of Schaffhausen was not in existence. The Rhine glacier reached to the castle of Laufenburg, where

tremendous layers of rock stopped its advance and compelled it to flow as the Rhine through the Klettgau. The large Rhine plain between Basel and Bingen probably formed an inland sea.

The region of the Schweitzerbild, therefore, was a sunny oasis in the midst of the frosty world of ice, sought by man and beast, who fought here the fight for existence, with and against each other.

What thoughts actuate the modern explorer when he tries to penetrate into the life and ways of those long past generations of immeasurable periods of time! Periods which are counted by the many, many thousand years. Some astronomers place the last ice period not less than 200,000 years back of our present time. Not in vain does science attempt to bring light into their mysterious region, for in the images of the past is the future foreshadowed. To close, it is to be mentioned that the whole outcome of these excavations, which will be continued in the Spring, will be published in a scientific work, for which a number of scientists have promised their collaboration; but the completion of that work will, naturally, take some time on account of the mass of material that needs investigation and study by specialists.

HOW A TECHNICAL STUDENT CAN PROFITABLY USE THE COLLEGE LIBRARY.

Students rarely realize the fact that the college library affords them a better opportunity for research and improvement, than will probably ever recur in the busy life which is to follow the day of graduation. A large library, selected with care, is a record of the accumulated experience of all the ages. One generation rejects the follies of those preceding, retains that which is good, and on the permanent printed page notes the reasons for its conclusions, and suggests modes of work for the future, whereby both the individual and the race may attain greater happiness. The shelves of the library contain these records, from the old sheep-bound tomes in antique type, printed three and four hundred years ago, down to the modern volumes which are now published almost every day in profusion. Theology, science, histories of nations and peoples, fine arts, technology, experiments, computations—all these and more are placed on permanent file, open to him who can find and read. Around the library should center the intellectual activity of the college, for here it is that the present comes in contact with the past and builds for the future.

The technical student may advantageously use the library in two way—first, for general consultation and readings; and secondly, for special consultation and research. In the first way, the student selects for his reading such subjects and authors as please his fancy, both literary and scientific, his selection being guided by no particular intention. In the second way he has before him a definite subject upon which he desires the fullest and most reliable information, in order that he may be able to thoroughly understand what has been done in the past concerning it and what are its future potentialities. Both these methods are certainly important, useful, and, when properly carried on, of the highest educational value.

The young man who has the privilege of wandering at will through the alcoves of a large and well selected library, who can

take from the shelves book after book, glancing at titles and prefaces, reading for an hour when suggestive subjects are found, or for a few moments only when his sympathy is not aroused, enjoys a rare privelege. Thus it is that inclinations are awakened toward certain lines of thought, that curiosities are excited concerning matters previously almost unknown, and that often a true spirit of research is developed. It almost seems as if the student who, with an earnest love of books, follows this plan comes into contact with the personalities of the authors. Let him then try to examine the works of masters, of those whose opinions and methods have been found sound, and of those who have impressed the world by their utterences. It will not be always possible for the student to read thoroughly the writings of such men, but he should not therefore pass by their books. The Principia of Newton is now but little studied, yet it is one of the books which moved the intellectual world, and every college student should be glad to turn over its pages for an hour in the endeavor to gain a glimpse of the methods of that great mind.

Another advantage of this first way of using a library is that it affords opportunity for recreation. No one wishes to read continually upon the subjects of his special profession. The busy man at work must have side issues to which he turns for refreshment and amusement. Novels, travels, histories, and polemics afford change and relaxation from the regular professional reading of the technical man. One civil engineer amuses himself with the study of sociology, a second becomes interested in the archæology of ancient Egypt, a third reads everything to be found on Arctic exploration, a fourth collects old almanacs and rare Americana, a fifth is a mineralogist, and here and there is found a metaphysician. In all these directions and many others, the college library affords opportunities to the student which he should not neglect in his hours of leisure.

But this article was mainly undertaken in order to give a few hints to the technical student as to the second way of using the library, namely for special consultation and research. Cyclopædias and text-books furnish general outlines, the fundamental principles, and the best known facts. Technical and scientific journals, and the transactions of societies, contain the special

articles which record the investigations themselves. By turning over the pages of these periodicals, or using the indexes of the yearly volumes, the information sought may sometimes be found, but this is a slow and uncertain method, for the number of volumes to be examined will usually be very great. It is, however, by the help of special indices and bibliographies that such investigations are most advantageously carried on, and it may be a benefit to some students if a brief account of those most important for engineers be given.

Besides the annual indexes, many journals and transactions issue subject indexes covering periods of ten or twenty years. There is a very good index to volume I–XXI of *Transactions of the American Society of Civil Engineers*, comprising the years 1852–1889; this includes both authors and subjects, arranged in one alphabet, and by its use one can quickly ascertain if any given subject has been discussed in the volumes covering those years. The *Proceedings of the Institution of Civil Engineers* have been for several years provided with what is called "a brief subject index," each of which covers all the volumes issued since 1879. *Engineering News* has published a general index of the more important articles in its volumes for the years 1874–1890, inclusive.

In case the student does not know what journals to consult, it will be advisable for him to use an index which includes the contents of a number of them. *An Index to Engineering Periodicals* for 1883–1887, inclusive, by Francis E. Galloupe, includes eighteen of the most prominent American and English journals, and the second volume, covering the year 1888–1892, will also embrace the transactions of engineering societies. Another work of particular value is the *Descriptive Index of Current Engineering Literature*, published by the Association of Engineering Societies, the first volume of which includes the years 1884–1891, inclusive; this gives brief notes concerning the contents of the different articles which will prove of much assistance to students, and it covers a wider range of periodicals than any other technical index except Kerl's *Repertorium*. The numbers of the *Journal* of the Association of Engineering Societies, published monthly, give regularly lists of current articles which are later to be gath-

2

ered together to form a second volume of the Descriptive Index. Prof. J. B. Johnson, of Washington University, St. Louis, who has had charge of this Index from the beginning, in 1884, has done a work of great value to the engineering profession.

If the research is to cover the widest possible field, journals in foreign languages must be consulted. Kerl's *Repertorium der Technischen Literatur*, published annually at Berlin, is an index of the most important engineering periodicals printed in English, French, German and Italian. The titles of the articles are given as in the original, but the classification is done in the German language. Still a student who does not read German can use it very well with a little help from a technical dictionary. For instance, if he is in search of articles on snow plows, he must first ascertain the German word for snow plow, and then turning to the *Repertorium* for that word in its alphabetical order he there finds the titles of a large number of discussions, with references to the volumes and pages of the journals where they appeared. This *Repertorium* extends back to the year 1853, and is preceded by a single volume, edited by Schubarth, which covers the years 1800–1853.

A most useful collection of titles of articles, classified according to authors, is the *Royal Society Catalogue of Scientific Papers*, of which volumes I–VI cover the years 1800–1863, and volumes VII–VIII the years 1864–1873. This is limited to pure science, and hence does not contain technical articles written from a utilitarian point of view. As, however., the student of engineering is as often in search of mathematical or physical investigations as of practical economic discussions, this catalogue will prove of constant value in his use of the library.

Two very valuable publications are the annuals *Die Fortschritte der Mathematik* and *Die Fortschritte der Physik*, the former now embracing twenty and the latter forty-two volumes. These give not only the titles of articles appearing on the subjects of mathematics and physics in all languages, but also statements of their contents or conclusions. By the use of these the student is able to gain glimpses of the problems which scientists all over the world are endeavoring to elucidate, together with their methods of work and the conclusions which they have reached. These

publications index and review books as well as papers in periodicals.

There are no publications, unless it be the catalogues of booksellers, which index and classify books and pamphlets over the entire field of engineering. There are very few lists of bibliographies devoted to special departments, although such are of the greatest value in forming a comprehensive view of the special literatures. Geodesy and surveying, however, are well provided for in the excellent *Bibliography of Geodesy*, by Prof. Gore, published in the Report of the U. S. Coast and Geodetic Survey for 1887, while annual lists for later years may be found in the columns of *Zeitschrift für Vermersungswesen.* The American Society of Civil Engineers has published a list of 186 pages of titles of books and pamphlets which are found in its library on the subject of railroads. But what has been done is very little compared with what remains to be done. It is to be hoped that the conference on engineering education to be held next August at Chicago, in connection with the engineering congresses, may have this subject before it for discussion, and that some plan of coöperation may be devised which will produce for technical students a comprehensive index catalogue which shall be both a trustworthy guide and a source of inspiration in their researches.

In conclusion let me give to every young man who has the privilege of using a large library the hint that it is almost as important to know where knowledge can be found as it is to be in possession of it. In a certain sense it is more important, for no one can gain a thorough knowledge of even a single specialty in these days of rapid discoveries, yet if he knows how to find information and to use it, he can have many specialties at his command.

> "Index learning turns no student pale,
> Yet holds the eel of science by the tail."

M. M.

NOTES ON ROPE DRIVING.

BY J. J. FLATHER.

PART II.

It was stated in the first part of these Notes that the differential driving effect was one of the principal causes of wear in a rope and a large factor in the loss of power transmitted; and that to reduce this to a minimum, ropes should be of the same make and degree of hardness, of uniform diameter, similarly spliced, having the same amount of sag, and run over grooves of uniform diameter. It is evident that in practice it would be impossible to maintain these conditions, even if it were practicable to overcome the mechanical difficulties and install a plant under the given requirements.

To prevent this slip and consequent wear of the rope and groove, and to equalize the tension in each member, Mr. John Walker, of Cleveland, has patented a differential driving pulley with loose grooved rings in its rim.

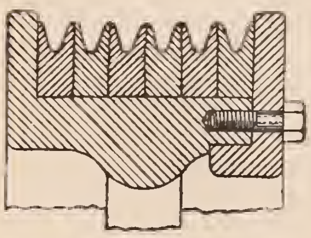


FIG. 3.

Originally intended for cable railway machinery where the wear on the drums due to the wire cable is excessive, the differential principle has been extended to other uses—notably elevator sheaves and rope transmission pulleys.

In the latter the rope is led over a number of separate rings, Fig. 3, adapted to turn loosely and independently of each other on the smooth circumference of the drum.

While the rope is passing over the pulley the tendency of the rings will be to adjust themselves to the strain in each member by moving around the circumference of the drum; thus the driving tension is equalized and each rope is brought to do its own share of the work without slipping in its groove. These rings have a diametrical friction, due to the pressure of the rope in the groove

transferred to the flat surface of the drum; the combined friction of the several rings being sufficient to drive the rope, or pulley, as the case may be.

As rope driving has, until recent years, been a matter largely of experiment, and, moreover, as the conditions under which the systems were installed have been so varied, it is not surprising to find many cases where the ropes have been rapidly worn out and replaced by leather belting or other systems of transmission.

Actual experimental knowledge has been obtained slowly, on account of the varying periods required to determine the data; a good rope lasting from three to six years, and a poor rope, not properly arranged for the work, wearing out in as many days. In many of the early applications, so great a strain was put upon the rope that the wear was rapid, and success only came when the work required of it was greatly reduced. As previously noted, the size, form and condition of the pulley sheave bears an important part in the life and efficiency of a rope; so that at the present time, with the results of actual trial before us, the conditions which will secure reasonable efficiency and durability are approximately known. According to Mr. Charles W. Hunt,* of New York, plants which have been successful, as well as those in which the wear of the rope was destructive, indicate that 200 pounds on a rope one inch in diameter is a safe and economical working strain.

Unwin assumes a breaking strength on untarred ropes of from 7000 to 10,000 pounds per square inch, depending to a certain extent on the amount of twist given to the rope.

Assuming a working factor of 8, the working strength would thus become about 1200 pounds per square inch of section or 750 pounds for a rope one inch in diameter, but this—in the light of more recent knowledge—is much too high when the wear and friction of the bearings and ropes are taken into account.

Recent tests of American ropes show an average breaking strength of about 7100 pounds for ropes one inch in diameter. The cross-section of a three-strand rope in which d_1 is the diameter of a single strand, is $3\left(\frac{\pi}{4}d_1^2\right)$, whence d_1 bears the following

* Trans. A. S. M. E. 1891.

relation to the diameter, d, of the circumscribing circle:

$d = d_1\left(1 + \frac{1}{\cos 30^\circ}\right) = 2.15\ d_1$; from which we obtain the cross-section $a = 3\left[\frac{\pi}{4}\left(\frac{d}{2.15}\right)^2\right] = \frac{\pi}{6.16}\ d^2$.

On account of the spiral twisting of the strands and their compression upon each other, this may be taken equal to $\frac{\pi}{5}\ d^2$, that is, we may assume that the sectional area of a hawser-laid rope is equal to about eight-tenths of the area of the circumscribing circle. This would give a breaking strain for the above ropes, per square inch of section, of about 11,000 pounds. Following the deductions of Mr. Hunt, that 200 pounds should be allowed as the working strain on a manila rope one inch in diameter, we note that the normal working strain is about one thirty-fifth of the ultimate strength. As the splice will weaken the rope from 25 to 30 per cent., this would make the normal working strain about one twenty-fifth of the strength of the splice. The actual strains are, however, generally considered to be much greater, due to vibrations in running, imperfect tension mechanisms, defects in construction and other causes.

From data furnished by the manufacturers of rope belting, Prof. Unwin showed, from cases in practice, that the difference of tension on the two portions of the rope is equal to 75 to $80d^2$, that is:

$$T_1 - T_2 = P = 75 \text{ to } 80d^2,$$

where T_1 = tension on driving side of rope
T_2 = tension on slack side and,
P = driving force.

It can be shown (see page 90,) that the value of the ratio $\frac{T_1}{P}$ varies from $1\frac{3}{4}$ to $2\frac{3}{4}$ in ordinary practice, depending upon the speed of the rope, the coëfficient of friction, and the arc of contact between rope and pulley.

If we assume an average value of 2.25 we shall obtain

$$T_1 = 2.25 \times 75 \text{ to } 80d^2 \text{ or}$$
$$T_1 = 168 \text{ to } 180\, d^2$$

a value we have assumed, somewhat less than that which Mr. Hunt gives.

Reuleaux, in his more recent notes on rope driving, assumes 350 pounds per square inch of section for the working strength of hemp rope; the section being taken as that due to the full outside diameter of the rope.

The ropes most commonly found in use are from ⅝ inch to 1¾ inches in diameter, although smaller sizes are frequently employed with good results; in one case, cited by Mr. T. S. Miller,* a rope no larger than $\frac{5}{16}$ inch diameter, is used very satisfactorily to transmit 20 horse-power.

In Germany larger sizes are used—in ordinary cases the ropes will vary from 1½ to 2½ inches in diameter, but as a rule the larger diameters of rope are not as economical, either in first cost or maintenance. Rather than adopt such large diameters it will generally be found more advantageous to use a greater number of small ropes over wider pulleys, or else to run the latter at a higher velocity or greater tension and replace them more frequently.

With a given velocity of driving rope, the weight of rope required for transmitting a given horse-power will be the same irrespective of diameter of rope. The smaller rope will require more parts, but the weight will be the same. The relation between the ultimate strength, weight per foot of length, working strain, and the diameter of rope may be ascertained from the following equations, which have been deduced from the previous assumptions:

Let $d =$ diameter of rope in inches;
$W =$ weight of rope in pounds per foot;
$B =$ breaking strain;
$T =$ working strain;

then
$$W = 0.32\ d^2$$
$$B = 7000\ d^2$$
$$T = 200\ d^2$$

In determining the horse power which a rope will transmit under given conditions, the centrifugal force due to the velocity and weight of rope is an important factor and should be considered

* Trans. A. S. M. E., 1881.

in all cases, as with high velocities the loss of power from this cause is very great.

The centrifugal force in any case can be determined from:

$$F_o = \frac{w\,R\,d\alpha}{g}\,\frac{v^2}{R} = \frac{wv^2}{g}$$

where w = the weight of rope per unit length; $d\alpha$ = angular measure of a unit's length on circumference of pulley;

R = radius of pulley.

In terms of the diameter of rope this would give, per unit's length,

$$F_o = \frac{0.32\,v^2\,d^2}{32.16} = \frac{v^2\,d^2}{100} \text{ nearly.}$$

At a speed of about ninety feet per second, the centrifugal force increases faster than the power from increased velocity of the rope, and at 140 feet per second this force equals the assumed allowable tension in the rope, viz., $200d^2$ pounds. Computing this force at various speeds, and then subtracting it from the assumed maximum working tension, there is obtained the force available for transmission of power. The whole of this force, however, cannot be used, because a certain amount of tension on the slack side of the rope is necessary for adhesion to the pulley. This tension is uncertain, as there are no conclusive experiments which give reliable data for its determination: the coëfficient of friction, ϕ, as stated by various authorities, varying all the way from 0.075 up to 0.88.

Reuleaux quotes the experiment of Leloutre and others as indicating a value of 0.075 for cylindrical pulleys with new hemp rope, 0.088 for semi-circular grooves, and 0.15 for a wedge groove of 60°.

Experiments by the Messrs. Pearce Bros. of Dundee, give a value of ϕ equal to 0.57 to 0.88 for ropes on ungreased pulleys, and $\phi = 0.38$ to 0.41 when the pulleys are greased.

Unwin states that the coëfficient of friction for ropes on a flat metal pulley is equal to 0.28, from which the actual coëfficient for a grooved pulley is obtained by multiplying 0.28 by the cosec. of half the angle of the groove. For an angle of 45° this would

give $\phi = 0.72$. These latter values are probably very much higher than is ordinarily found in recent practice with well lubricated ropes.

From a consideration of the various experiments, and many cases of successful rope drives it would appear to the writer that, for ropes which are partly worn and sufficiently lubricated to wear well, a value of 0.12 for a flat surfaced metal pulley would enable a working coëfficient to be determined.

For a groove of $30°$ this would give $\phi = 0.12 \text{ cosec. } \frac{30°}{2} = .46$

" " " $45°$ " " " $\phi = .12 \text{ cosec. } \frac{45°}{2} = .31$

" " " $60°$ " " " $\phi = .12 \text{ cosec. } \frac{60°}{2} = .24$

If the arc of contact on smaller pulley, and the coëfficient of friction between rope and sheave are known, the tension on slack side of the pulley, and hence the horse-power transmitted can be readily determined from the following considerations.* Assuming as before that the driving force P is equal to the difference in tension T_1 on the driving side of the rope and T_2 on the driven side, and noting that the driving force must equal the friction F between the surfaces, we obtain

$$T_1 - T_2 = P = F.$$

The friction, F, depends upon the arc of contact α between the rope and its sheave, the coëfficient of friction ϕ and upon the centrifugal force F_0, set up in the rope, due to its velocity and weight.

To determine the values of F, T_1 and T_2, it will be necessary to assume a given tension in the rope, also its speed and weight, coëfficient of friction and arc of contact.

Let $S =$ stress in rope at any point on the pulley.
$T =$ allowable working tension.
$f =$ abbreviation for $\frac{w}{g} \frac{v^2}{T} = \frac{F_0}{T}$
$w =$ weight of rope one foot long.

* See Reuleaux, § 264, also, Prof. Klein's Notes on Machine Design.

$v =$ velocity of rope in feet per second.

The centrifugal force of an element of the rope is:

$$F_o = \frac{w}{g}\frac{S}{T} v^2 \, d\alpha = f \, S \, d\alpha \, .$$

As the pressure, p, on the sheave is diminished by the centrifugal force, and as the difference in the tension of two consecutive elements of the rope just equals the friction we have

$$d\, S = \phi \; (p - F_o)$$

hence $d\, S = \phi \; (S\, d\alpha - f\, S\, d\alpha\,) = S \phi\, (1 - f)\, d\alpha$

$$\text{or } \frac{d\, S}{S} = \phi \; (1 - f)\, d\alpha$$

Integrating,

$$\int_{T_2}^{T_1} \frac{d\, S}{S} = \int_o^\alpha \phi \; (1 - f)\, d\alpha \; ,$$

$$\text{hyp. log. } \frac{T_1}{T_2} = \phi \; (1 - f)\, \alpha$$

from which we obtain,

$$\frac{T_1}{T_2} = e^{\phi\alpha} \; (1 - f)$$

$$\text{or } T_1 = T_2 \left(e^{\phi\alpha \; (1 - f)} \right)$$

in which ε is the base of hyp. log. $= 2.7183$,

therefore $T_1 - T_2 = P = T_2 \left(e^{\phi\alpha \; (1 - f)} \right) - T_2$

$$= T_2 \left(e^{\phi\alpha \; (1 - f)} - 1 \right)$$

If we assume $\dfrac{T_1}{T_2} = r$ we obtain

$$\frac{r}{r - 1} = \frac{T_1}{T_1 - T_2} = \frac{T_1}{P} .$$

These ratios, r and $\dfrac{r}{r - 1}$, Reuleaux calls the friction modulus and the stress modulus respectively.

As the weight of a manila rope one foot long $= 0.32\, d^2$, the value of f for varying speeds can be determined from:

$$f = \frac{w\,v^2}{g\,T} = \frac{0.01\;d^2\;v^2}{T};$$

if now we assume a constant working stress $T = 200\;d^2$, then

$$f = \frac{0.01\;d^2\;v^2}{200\;d^2} = 0.00005\;v^2.$$

From these assumptions the following table of the values of $1-f$ has been computed:

Velocity in feet per min.	Values of $1-f$.	Velocity in feet per min.	Values of $1-f$.
2000	0.94	5500	0.58
2500	.91	6000	.50
3000	.87	6500	.41
3500	.83	7000	.32
4000	.78	7500	.22
4500	.72	8000	.11
5000	.65	8500	.0

TABLE I.—VALUES OF $1-f$ FOR A WORKING STRESS EQUIVALENT TO $200d^2$ POUNDS.

Since $f = \frac{F_o}{T}$ it will be seen from the above that when the velocity of the rope is as great as 8500 feet per minute, the centrifugal force just equals the allowable working stress.

In average work the lesser arc of contact embraced by the rope—generally on the smaller pulley—will be about $0.9\,\pi$, and this value may be assumed for approximate calculations with a working degree of accuracy. If the angle in degrees is known, its value, α, in circular measure, can be obtained from the following table:

Degrees.	Circular Measure. α	Fraction of Circumference.
105	1.83	0.29
120	2.09	.33
135	2.35	.37
150	2.62	.42
165	2.88	.46
180	3.14	.50
195	3.43	.54
210	3.66	.58

TABLE II.—ANGLE EMBRACED BY ROPE.

If we now assume the coëfficient of friction ϕ to be 0.31 for a 45° groove we may obtain the value of the expressions:

$$\frac{T_1}{T_2} = e^{\phi\alpha(1-f)} \text{ and}$$

$$\frac{T_2}{P} = \frac{r}{r-1}.$$

In order to simplify calculation the following table contains values of r and $\frac{T_2}{P}$ which will enable the horse-power transmitted by a rope to be determined with a degree of accuracy depending upon the assumption of the coëfficient of friction.

$\phi \propto (1-f)$	$r = \frac{}{T_2}$	$\frac{r}{r-1} = \frac{T_1}{P}$
0.1	1.11	10.41
0.2	1.23	5.40
0.3	1.35	3.86
0.4	1.49	3.03
0.5	1.65	2.54
0.6	1.82	2.22
0.7	2.01	1.99
0.8	2.22	1.82
0.9	2.46	1.69
1.0	2.72	1.58
1.1	3.00	1.50
1.2	3.32	1.43
1.3	3.67	1.37
1.4	4.06	1.33
1.5	4.48	1.29

TABLE III.—FRICTION AND STRESS MODULI.

The following application will show the use of the tables. Let it be required to determine the horse-power transmitted by a rope 1¼ inches diameter running at a velocity of 4000 feet per minute over a pulley with 45° grooves. Assuming an arc of contact of 165° we find from Table II $\propto = 2.88$; for the required velocity, 4000 feet per minute, Table I gives 0.78 as the value of $1-f$, therefore assuming the coëfficient of friction $\phi = .31$ we obtain:

$$\phi \propto (1-f) = 0.31 \times 2.88 \times .78 = .69.$$

From Table III the value of $\frac{T_2}{P}$ corresponding to 0.69 is about 1.99, and as $T_1 = 200\, d^2 = 312.5$ we find

$$P = \frac{T_1}{1.99} = 159 \text{ lbs.; since } \frac{PV}{33000} = HP \text{ there is obtained}$$

$$HP = \frac{159 \times 4000}{33000} = 19.$$

For any special case where the data are known or may be determined, the formulas and tables already given should be used to ascertain the horse-power transmitted or diameter and number of ropes required for a certain work as the case may be. For average work, however, it will be found that the assumed values of α and ϕ previously noted, will give very satisfactory results, and upon these assumptions the writer has computed the following Table of Horse-Power for various sized ropes, running at varying speeds.

Velocity of rope in feet per minute.	Diameter of rope.						
	5/8	3/4	1	1 1/4	1 1/2	1 3/4	2
2000	2.7	3.8	6.8	10.7	15.4	20.9	27.3
2500	3.3	4.7	8.4	13.1	18.8	25.6	33.5
3000	3.8	5.5	9.7	15.4	21.8	29.7	38.9
3500	4.3	6.2	11.1	17.3	24.9	34.0	44.3
4000	4.7	6.8	12.1	18.9	27.3	37.2	48.6
4500	5.0	7.2	12.9	20.1	29.0	39.4	51.6
5000	5.2	7.4	13.3	20.7	29.9	40.6	53.1
5500	5.2	7.6	13.5	21.1	30.4	41.4	54.1
6000	5.1	7.3	13.0	20.3	29.3	39.8	52.1
7000	4.1	5.9	10.5	16.5	23.7	32.3	42.2

TABLE IV.—HORSE-POWER TRANSMITTED BY ROPES.

The graphic representation of these values shows very clearly the effect of centrifugal force in diminishing the power transmitted under an assumed working tension, and would indicate that with tensions of 200 d^2 pounds the speed should not exceed 5500 feet per minute.

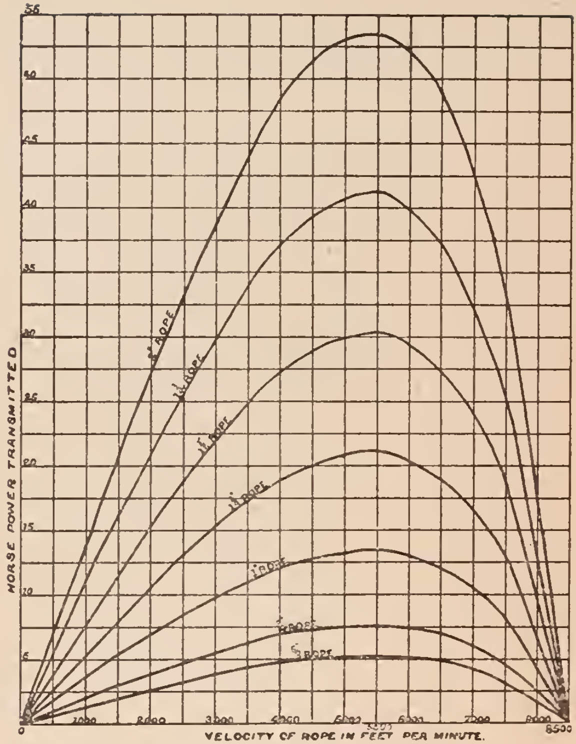
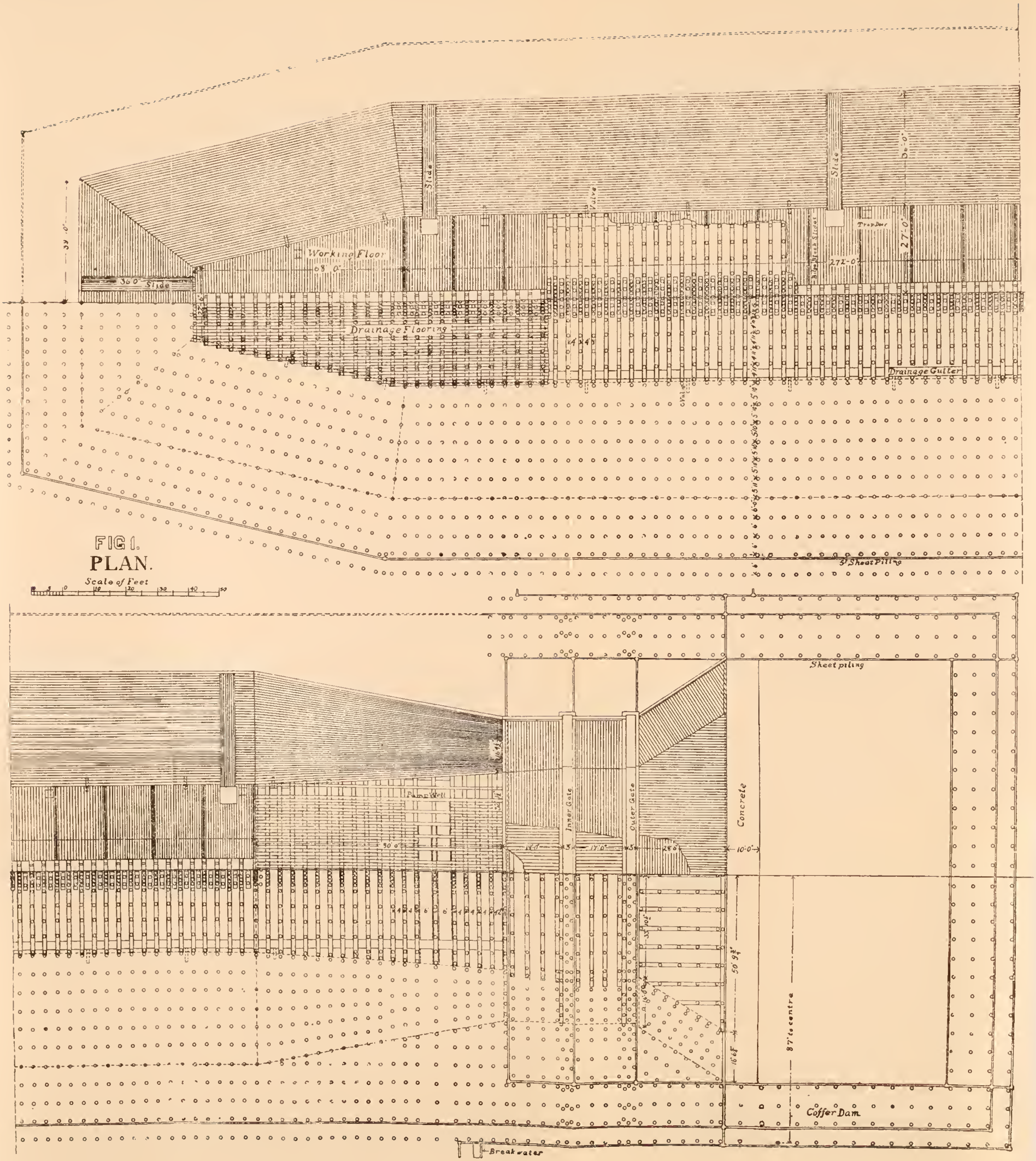


DIAGRAM OF HORSE-POWER TRANSMITTED BY ROPES WITH MAXIMUM TENSION = 200 d^2 POUNDS.



Slide
36' 0"
Working Floor
68' 0"
Valve
Trap Door
27' 0"
272' 0"
Drainage Flooring
Drainage Gutter
5' Sheet Piling
Scale of Feet
Pump Well
50' 0"
Inner Gate
Outer Gate
17' 0"
28' 6"
Concrete
10' 0"
Sheet piling
50' 9¾"
87' to centre
Coffer Dam
Breakwater

FIG 1.
PLAN.

A DESCRIPTION OF THE TIMBER DRY-DOCK UNDER CONSTRUCTION AT PORT ROYAL, S. C.

A dry-dock is an artificial basin or inclosure supplied with gates for the admission of ships, and with pumps for emptying the dock when the vessels have been admitted and the gates closed.

The essential features of a dry-dock are: First, a basin large and deep enough to admit vessels of the draught for which it is designed. Second, a gate so constructed as to be readily opened and closed, and yet fitting snugly enough to keep out the water when the dock is empty. Third, a pumping plant of sufficient capacity to empty the dock in a reasonable length of time.

Considering these features in their order, we have:

I.—The Basin.

The basin of this dry-dock may be described in general terms as a timber-lined hole in the ground, for the top of the finished structure is about on a level with the surface of the ground. The depth of this hole from surface to sub-grade of the floor is 38 feet; its width at sub-grade 60 feet, at the surface 126 feet; its length from the head or in-shore end to the sea is 550 feet.

The lining or timbering of this cavity is of hard, long leaf yellow pine, firmly secured to a foundation of over 6000 long leaf yellow pine piles, arranged as shown on the accompanying plan, Fig. 1. The gate sills, keel, and bilge blocks are of oak. All timber exposed to the attack of the ship-worm (*teredo navalis* and *limnoria*) or the weather, is impregnated with fourteen pounds of creosote oil to the cubic foot of timber.

The general appearance of the finished structure is that of an immense coffin, of which the gate forms the foot, while the head and sides, instead of being vertical, rise at an angle of 45° from the floor of the dock to the surface of the ground.

So much for the general description of the basin. Before considering the structure more in detail, it would, perhaps, be well

to enumerate the problems to be solved in its design and construction.

1. The whole basin must be sufficiently water tight to keep ground-water from freely leaking into the dock when it is empty, and the water in the full dock from leaking out. Such an in and outflow would soften and undermine the banks, and tend to produce sliding and caving, besides adding to the cost of pumping leakage when the dock is empty.

2. The sides must be designed to withstand the thrust of the water when the dock is full, the thrust of the banks when the basin is empty, and the pressure of the sea on the gate, transmitted through the sill to the sides, when there is no water in the dock.

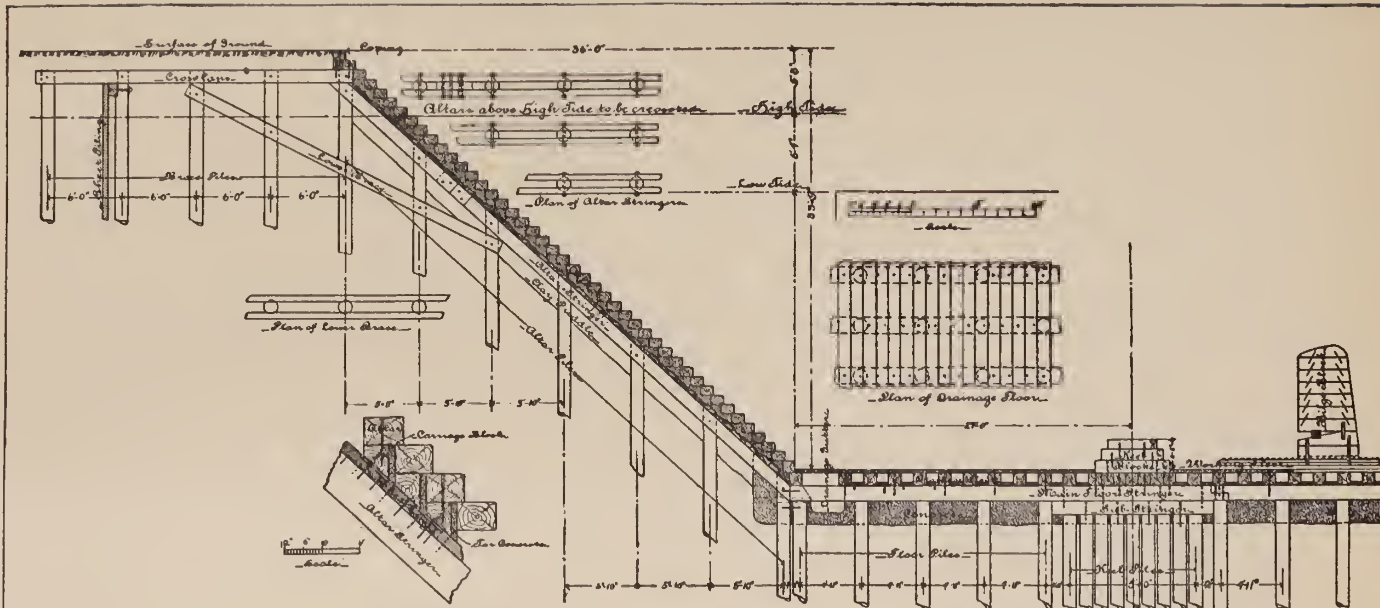
3. The bottom of the dock must be strong enough to bear the entire weight of a ship concentrated along a narrow strip down the middle of the dock floor.

Fig. 1 is a general plan of the dock basin. The portion above the axial line represents the finished dock, while the lower half shows the spacing of the piles, and the arrangement of the floor timbers.

The general structure of the dock shows the piles in rows or bents four feet apart, centre to centre, extending transversely across the basin. Each of these bents carries the timbers forming what might be termed a rib of the dock. These ribs constitute the frame-work of the basin. Their structure is more clearly represented in Fig. 2, which is a transverse section through the dock, and shows the construction of one side and one-half of the floor, the other side and the remainder of the floor being exactly similar in design.

Each "rib," as shown in Fig. 2, readily divides itself into three parts,—viz.: 1. The "cross-caps" or horizontal timbers on each side of the dock just below the surface of the ground. 2. The "altar stringers" or steps which form the sides of the dock. 3. The "floor stringer," on which the floor rests.

The "cross-caps" on each side consist of two 6″x 12″ timbers twenty-four feet long, which are securely bolted through tenons cut on the five "brace piles," as shown on Fig. 2. On the fourth row of brace piles from the edge or "coping" of the dock, is



Section through Altars and Floor

Figure 2.

shown a section of a line of 5 x 10 inch sheet piling, tongued and grooved and driven around the entire basin to as great a depth as practicable, for the purpose of shutting out ground water from the excavation, and preventing the banks from caving and sliding. The "brace piles," in addition to stiffening the banks, form an anchor for the altar stringers, to which they are tied by the "lower braces." Each lower brace is made up of two 6 x 12 inch timbers bolted through the piles with 1¼ inch screw bolts. Shown in plan and elevation in Fig. 2.

Each "altar stringer" consists of two 6 x 12 inch timbers bolted through tenons, cut on the altar piles, with 1¼ inch screw bolts 20 inches long.

A layer of well rammed clay puddle two feet thick, extending around the entire dock reaches to the upper face of the altar stringers. This is intended to keep any ground water, which may have passed the sheet-piling, from entering the dock.

Upon the altar stringers, a sheathing, made of alternate 3 x 12 and 4 x 12 inch planks, is securely spiked. This sheathing is shown to a larger scale in Fig. 3, which represents an enlarged section through the altars.

In the same figure, the carriage blocks one foot wide, are shown fastened to the sheathing and altar stringers with a half-inch drift-bolt 15 inches long. These blocks occur only at every other altar stringer, and are hence eight feet apart, measured horizontally. When a carriage block comes over a three-inch plank of the sheathing, a filling block one-inch thick is used to give the blocks an even bearing. Shown in Fig. 3.

Upon these carriage blocks the altars, consisting simply of 9 x 12 inch timbers, are fastened as shown in Fig. 3, with half-inch drift-bolts 15 inches long. The altars are laid on their 12 inch face one above the other, each lapping over the next lower end by two inches, thus forming a series of steps with 9 inch risers and ten inch treads from the floor of the dock to the coping, and extending around the entire basin clear to the gate. The space between the back of the altars and the sheathing is filled with tar concrete well rammed to fill all interstices.

The tar concrete is made by mixing hot, dry sand and gravel with boiling tar in the proportion of one barrel of tar to a cubic

yard of sand. The mixture is placed while hot, as it becomes crumbly when cold.

In considering the construction of the dock floor, it will be noticed that the floor piles near the axial line—marked "keel piles" in Fig. 2—are driven close together, and are cut off 14 inches below the other floor piles. These nine keel piles are capped with a "sub-stringer" 14 x 16 inches, 13 feet long, which is securely spiked to them by long drift bolts.

The main floor stringer, 14 x 16 inches in section, is made of two pieces spliced as shown, and extends between the toes of opposite altar stringers across the dock floor. It rests directly upon the sub-stringer and floor piles, and is fastened to them with drift bolts. In the main portion of the dock (see Fig. 1,) piles are driven between the main bents forming short intermediate bents of five piles each. These are capped with a 14 x 16 inch timber 13 feet long, laid with its top on a level with the upper surface of the main floor stringers.

All of the floor stringers are bedded in a layer of shell concrete three feet thick reaching to the upper surface of the intermediate and main floor stringers. The drainage gutters, shown in Fig. 2, on each side at the foot of the altars, are formed in this concrete, and are designed to carry all leakage to the pump well. The relief valves (Fig. 1) at the sides of these gutters are attached to terra-cotta pipes, extending through the concrete and puddling, which afford an outlet for the water which might otherwise accumulate behind the clay puddling.

The shell concrete mentioned above, is composed of one part Portland cement, two parts sand and gravel, and five parts oyster shells, all by measure.

Resting upon this bed of concrete and securely bolted to the floor-stringers, the drainage floor is laid. Beginning in the middle of the floor, there are seven 12 x 12 inch timbers placed side by side parallel to the axial line of the dock and extending down its entire length. The remainder of the drainage floor, from the edge of this central strip to the foot of the altars, is made up of alternate 3 x 12 and 12 x 12 inch timbers placed close together, parallel to the axial line, and securely fastened to the floor-stringers. This alternating of 3 x 12 and 12 x 12 inch timbers,

forms a series of longitudinal box drains (Fig. 2) which empty at intervals of 30 feet into transverse drains leading into the drainage gutters.

Upon the drainage floor, three-inch planks ten inches wide are laid half an inch apart, extending at right angles to the axial line, from the foot of the altars on each side to within three feet of the axial line. These planks form the working floor of the docks.

Keel blocks of oak, built as shown in Fig. 2, are placed four feet apart down the center line of the dock. Upon them nearly the entire weight of the ship in dock rests. For this reason it is necessary to have the foundation along the axial line particularly strong.

The bilge-blocks are of oak, and are constructed as shown in Fig. 2. They are placed at intervals of sixteen feet, and are operated on cast-iron racks by means of chains leading to the coping. They are designed to carry a portion of the ship's weight, and can be drawn close under the bilge of a vessel and adjusted to conform to the contour of its hull.

A careful study of Figs. 1 and 2, and a hasty recapitulation of the preceeding should serve to give a clear idea of the construction of the dock basin. Turning to Fig. 2, it should be remembered, first, that the brace, altar, floor, and keel piles, forming a line or bent transversely across the dock, occur at intervals of four feet throughout the entire length of the basin; second, that the cross-caps, lower braces, altar stringers, main floor stringers, and substringers, which together form a "rib" of the dock, are fastened to the above mentioned piles, and hence occur at intervals of four feet throughout the entire length of the dock; third, that the clay puddle, the sheathing, the tar concrete, and the altars are continuous around the sides of the dock; fourth, that the shell concrete, the drainage floor, and the working floor are continuous over the bottom of the dock.

The general dimensions of the finished basin are as follows:

Length on coping from head to inner gate, . . .	476 ft.
" " floor " " " " " . .	440 ft.
Width on coping at head, ...	79 ft., 8 in.
" " " " body, ...	126 ft., 0 in.

Width at entrance between abutments on mean high water line, ...	91 ft., 6 in.
Width on floor of dock at head, ...	22 ft., 6 in.
" " " " " in body, ...	54 ft., 0 in.
Depth, coping to mean high water line, . . .	5 ft., 3 in.
" " " working floor, ...	33 ft., 9 in
Draught at mean high water, over sill, . . .	26 ft., 0 in.
" " " " " " keel blocks, .	26 ft., 0 in.

II.—THE GATE.

The gate of the dry-dock, or the caisson, as it is most commonly called, is a structure built of steel plates, angles, deck beams and I bars. It is, in short, a double-ended hull built of steel, and hence a technical description of its construction in detail would involve so many terms in naval architecture as to render it unintelligible to one not versed in that science.

This steel hull measures 100 feet, 3 inches over all on deck, and 67 feet, 5½ inches over all at the bottom of the keel. Its extreme molded breadth is 23 feet, while the breadth of beam on the upper deck is only 13 feet. The extreme height, from the top of the deck to the bottom of the keel is 32 feet, 6 inches.

Unlike the hull of a ship both ends of the caisson are alike in shape, and since the length on the keel is so much less than the length on deck, the "stems" (the rectangular boxed columns connecting the ends of the keel with the bow and stem ends of the deck) though straight are not vertical, but are set at an angle so as to make them parallel to the sides of the dock at the entrance.

The stems, like the keel, are rectangular in section, being twenty-four inches wide by seventeen inches straight depth, and then rounding to the form of the caisson. The sides of the stems and keel thus form a plane surface, seventeen inches wide, which borders the curved portion of the caisson and comes in such close contact with the gate sill as to keep out the water.

The dock under consideration is designed with what is known as a double sill. The main sill is an oak timber 16 x 18 inches which extends across the floor and up the two sides of the dock basin. This timber is faced with corrugated rubber and the sides

of the stems and keel of the caisson are pressed tightly against this rubber when the gate is closed, and the dock partly or entirely empty. The pressure which holds the gate against the sill is due to the difference of head between the water of the harbor and the water in the dock. The secondary sill is a pine timber 12 x 18 inches, extending parallel to the main sill and three feet from it. A groove three feet wide is thus formed across the floor and up the two sides of the basin, into which the keel and stems of the gate fit.

The caisson has two decks, the upper one of wood and the lower or main deck of steel. This main deck carries a centrifugal pump capable of discharging 1200 gallons per minute, for the purpose of emptying the ballast tanks with which the gate is supplied. These ballast tanks are of such capacity that when filled with water they will sink the caisson until the keel is grounded. The entire hull below the main deck constitutes the ballast tank, and water is admitted through two eighteen inch culverts controlled by suitable valves.

Below the main deck the gate is pierced by ten filling culverts twenty inches in diameter. They are simply steel pipes built into the caisson, which permit the water to flow through it, when the valves, with which each culvert is supplied are open. These valves are operated from the main deck.

The method of manipulating the gate is simple and covers two cases: 1. When the dock is filled with water and it is desired to close the gate and empty the dock. 2. When the gate is closed and the dock empty and it is desired to open the gate and fill the dock.

In the first case, the caisson with its ballast chamber partly empty is towed into position just over the gate sill. When it has been carefully moored in the proper position, water is admitted into the ballast tank. As the water enters the gate gradually sinks until the keel and stems rest in the groove of the gate sill. The water can then be pumped out of the dock and as it falls, the difference in head between the water of the harbor and the water in the dock becomes greater and greater, and the caisson is more and more firmly pressed against the rubber faced sill.

In the second case, the caisson is in position at the gate sill and the first operation is the opening of the valves in the filling culverts. The water rushes through and fills the dock thus equalizing the head and pressure on both sides of the gate. The centrifugal pump on the caisson is next set in motion, and the ballast chamber is emptied. As the water leaves the chamber the gate gradually rises until it floats free of the sills. It is then hauled to one side and free entrance and egress is afforded any vessel desiring to enter or leave the dock.

III. The Pumping Plant.

The pumping plant for emptying the dock consists of two centrifugal pumps with 42-inch suction and 40-inch discharge openings. The pumps when running together are required to deliver 70,000 gallons per minute, averaged from mean high tide to the dock floor. They are to be so located that the greatest lift does not exceed 28 feet, of which not more than 21 feet is to be below the center line of the pumps. As the distance from mean high water to the dock floor is 28 feet 6 inches, the pumps must be placed in a pit with their center line below mean high water.

To keep the dock free from leakage, after it has been emptied by the large pumps, a 12-inch centrifugal pump, capable of discharging 4,000 gallons per minute, is included in the plant. This is called the drainage pump.

The large pumps are operated by two 24x24 inch vertical engines provided with balanced valves. Each engine has a five foot five inch fly-wheel, and is secured to a heavy bed plate of cast iron in common with its pump. The engines work under eighty pounds boiler pressure. The drainage pump is driven by a 12x12 inch vertical engine secured to the common bed plate.

The steam generating plant for these engines consists of three cylindrical, horizontal, return tubular boilers, each seventy-two inches in diameter by sixteen feet long, and containing eighty 4-inch tubes sixteen feet long.

This entire plant—pumps, engines, and boilers—is located in the "Boiler and Pump House," which is a structure of brick 43x63 feet with wrought iron roof trusses and a slate roof.

The building is located near the water front and at one side of the dock, 121 feet from axis of dock to center of boiler house.

The water from the dock flows through a circular brick tunnel eight feet in diameter, from the drainage well to the foot valves at the ends of the suction pipes, and is then lifted and forced by the pumps through the discharge pipes and discharge culvert into the sea.

The discharge culvert is a covered trough, built of timber on a pile foundation and lined with concrete. It is ninety feet long, fourteen feet wide, eleven feet deep, and has the floor at the level of mean low water.

The contract price for the complete dry-dock is $430,000, and the time allowed for its completion two years. The dock was designed by O. von Nerta, C.E., of Washington, D. C., and is being built by Justin McCarthy, of Washington, D. C., under the supervision of Civil Engineer George Mackay, U. S. N.

EMIL DIEBITSCH, C.E., '89,
Principal Assistant Engineer.

SANITARY WATER ANALYSIS.

Pure water is unknown in nature. It is an artificial product of the laboratory. All natural waters contain foreign matter in solution and in suspension. The properties and fitness for various uses of waters are modified by the nature and quantities of these contained products. In case of water for drinking purposes, certain ingredients in quantity have been found to accompany ill effects upon health. A number of dangerous diseases, for example typhoid fever, cholera, scarlet fever, etc., are known to be propogated in a most remarkable degree in water. It, therefore, becomes a matter of grave importance to physicians and health officers to be able to test water for drinking purposes before its effects on the community shall have been demonstrated favorably or disastrously as the case may be; and it should be a matter of personal interest to all to know in a general way at least the principles involved in such an examination. In water analysis the

substances which attract attention as most important concerning health are those whose presence indicates contamination by animal matter. The presence of vegetable matter, though frequently undoubtedly harmful, is in many cases free from great objection. The water of the Dismal Swamp containing large quantities of the latter, is considered by many as excellent for drinking purposes. If animal matter is present the danger lies in the possibility that with it there are also present germs of disease communicated to the water either in excretion from animal bodies or in the decay of animal tissue All chemical methods throwing light upon the question as to the presence of organic animal matter are of value.

Besides this most important product, natural waters always contain mineral products in solution. These, however, are not generally present in sufficiently large quantity to be injurious to any alarming degree. Certain rare waters contain poisonous mineral products, such as salts of barium, arsenic, zinc, lead, chromium, etc. The determination of the mineral constituents is, however, comparatively easy if sufficient water be concentrated by evaporation. Certain gases, too, held in solution are readily pumped out and analysed.

The detection and determination of animal matter present is a problem not so easily solved; and since this point is the one most sought in the vast majority of analyses, it is undoubtedly of the highest importance. I shall discuss briefly the various methods in use by chemists. The first method described for the estimation of organic matter in water was discussed about forty years ago by Hofmann, Miller and Frankland. A quantity of water was evaporated to dryness and the residue strongly heated. The loss of weight by ignition was ascribed to organic matter burned away. But there is serious error in this process, inasmuch as some important mineral substances are decomposed at the increased temperature, so the method has been discarded as inaccurate.

In 1864, Welzien, and, two years later, Heintz proposed a method which was later improved and used by Frankland under the name of the combustion method. There are many modifications, but the principle was to evaporate a known weight of wate

to dryness, and determine the carbon and nitrogen in the residue by regular combustion. Frankland claimed that by the ascertained proportion of carbon to hydrogen it was possible to say whether the organic water present were of animal or vegetable origin. Subsequent workers have shown that there is considerable loss of carbon and gain of nitrogen by evaporation of quantities of water large enough to yield residues sufficient for combustion analysis. Other inaccuracies also cast serious doubt upon the method.

The fact that organic substances in general reduce potassium permanganate, thereby destroying its color, was noted in 1849 by Forschammer, and this point furnished a means of comparison of suspected waters with water known to be fairly pure, the basis of comparison being the quantities of standard permanganate salution reduced by known quantities of water. A solution containing a known weight of permanganate per cubic centimeter was added gradually to the water (according to Kubel, boiling hot, according to Tidy, cold, allowing to stand for three hours) until the pink color of the permanganate was faintly persistent. This method seems to possess many virtues, but has been called into question for the reason that it does not yield concordant results in duplicate analyses. The presence, too, of any reducing mineral substance in the water would obviously vitiate the results.

The method most largely in use, perhaps, in this country and in England was devised by Wanklyn, Chapman, and Smith, in 1867. It depends upon the following considerations: It is the nitrogenous organic matter in water that is harmful. In the process of decay, this is decomposed by minute organisms, and the nitrogen is converted slowly into ammonium compounds. Before decay, the substances present are supposed to be of albuminoid nature. It is claimed by Wanklyn, that if sodium carbonate be added to a known quantity of water and the latter be subjected to distillation, the ammonia in the distillate ("free ammonia") will represent the ammonium salts in the water and hence be a measure of decay that has taken place. If then a strongly alkaline solution of potassium permanganate be added and distillation continued, the albumenoid substances will, he

claims, be broken down and the ammonia collected in the second distillate (albuminoid ammonia) will be a measure of the undecayed organic matter present. This method yields valuable results, and is by far the easiest of application of those cited, requiring but little practice on the part of the analyst. It has, however, been justly criticised, as grave inaccuracies arise from incomplete condensation of the ammonia evolved, the difficulty of preparation of the alkaline permanganate solution free from ammonia, and from the fact that it is exceedingly difficult to break down many alkaloid substance by means of that reägent. Waters containing known weights of such substances have been subjected to its action with unsatifactory quantitative results. The method is, nevertheless, a popular one with chemists, and undoubtedly gives a fair general idea of the degree to which water is polluted by decayed or decaying substances. It tells to a degree the present and past condition of the water. If a large quantity of free ammonia is obtained and no albuminoid, there is probably less danger attending use of the water than if there is much undecomposed organic matter, as shown by excess of albuminoid ammonia; for in the former case the little organisms which are believed to effect putrefaction have done their work and have destroyed the organic matter, which would provide nourishment for harmful bacteria. Ammonia, then, obtained in water analysis is not objectionable in itself, but only in so far as it indicates the presence of conditions favorable to germs of disease.

Glancing over the methods which have been mentioned for the determination of organic animal matter in water, we find that there is not one that is thoroughly satisfactory. Much argument has been indulged in by their originators and followers, each being vaunted as the best and only accurate means of work; the only point of agreement among the various analysts being to decry every other person's process. Moreover, there is great difference of opinion on the part of authorities regarding certain other substances found in water. The presence of nitrates and nitrites is thought by Wanklyn to mean little in the matter of suspicious water, since he declares that they arise from oxidation of decayed organic matter, and that if danger formerly existed

it would now be past. Frankland claims that their presence places the water in doubt, on the ground that they are evidence of previous animal (not vegetable) contamination, and that contamination may be liable to occur again. Nitrates would be less objectionable than nitrites, inasmuch as they represent a stage farther removed from the conditions of putrefaction. The presence of chlorides is generally conceded to indicate, in most cases, pollution from sewage, sodium chloride being given off in large quantity in the excretions of animals. Even here, however, conclusions are altered by circumstances. If, in its course, the water has come in contact with sea water, or if it has flowed through strata containing salt deposits, the presence of chlorine would obviously be no evidence of sewage pollution.

Notwithstanding difference of opinion regarding methods and interpretation of results, a fair idea of the condition of water may be gotten by an experienced chemist by combination of the combustion, permanganate and albuminoid ammonia processes for determination of organic constituents and the determination of nitrates, nitrites and chlorine. In addition to the results of analyses, however, the history of the water and other extraneous conditions must be taken into account in drawing conclusions. If the water has percolated through chalk beds and fossil remains, it would be expected to contain certain quantities of nitrates which are of pre-historic origin and whose presence is not objectionable. As pointed out, the presence of chlorine may not indicate sewage contamination. The presence in quantity of organic matter together with nitrates, nitrites, and chlorine would render the water suspicious. If albuminous organic matter is absent and there are present ammonium salts, nitrates, nitrites and chlorine, the chemist might conclude that organic contamination has existed in the past. Under the circumstances he could not say whether or not the water is fit for use, for the decaying process may have removed the means of subsistence of the harmful germs a long time previous to the examination, so that these germs, if they were ever present may have died out. On the other hand a sufficiently long time may not have elapsed and, besides, the water may be subject to further additions of that organic matter, which had given rise to the formation of the above harmless products.

It will readily be seen that there may arise many cases in which the results of analyses are such that the chemist can not be perfectly sure regarding the sanitary properties of water, and in these cases his common sense and judgment must help him in his decision. Good judgment, however, usually comes with experience; and while a specialist in water analysis, who is at the same time an educated chemist, can, with a good deal of assurance, estimate the fitness of a water for use, mere analytical results and general knowledge frequently leave a less expert analyst in grave doubt.

Ill effects on the system in the shape of diseases, such as typhoid fever or cholera, are believed to have their origin in minute living organisms or bacteria, each disease having its peculiar causative germ. There are hundreds of different varieties of bacteria known.

The air we breathe is full of them, and the surfaces of all bodies are, under ordinary conditions, covered with them. Their functions in nature are much varied. The familiar phenomena of the souring of milk, fermentation, putrefaction of organic matter, and other changes are believed to be wrought by different varieties of these bacteria. By far the great majority of bacteria are without ill effect when taken into the system, but there are some whose functions, as stated, seem to be to produce disease, and without them disease can not exist. If the methods of the chemist were beyond criticism, the best he could do would be to ascertain whether the conditions in the water examined are, or are not, favorable to the presence of such bacteria. He could not say finally that the bacteria were present and in condition to generate disease. The conditions favorable to them may exist, yet they may be absent, so that water might contain animal matter without being dangerous to health. The chemist might under these circumstances condemn a harmless water. On the other hand in some cases germs of disease might be present with but little organic matter, and again the chemist's figures would be misleading. In other words, while the chemist from his analysis and shrewd judgment may with justice in most cases pronounce water suspicious or wholesome, his word should not and can not be taken as final. This point lies in the work of the biologist and bacteriologist.

Dr. Mallet of the University of Virginia, in 1881, tested the chemical methods current for the determination of organic matter in a most painstaking research. He pronounces them all subject to severe criticism. In estimation of the fitness of water for use, he recommends the use of all three, as each has points in its favor which the others lack; but he considers a biological examination as necessary in addition to chemical analysis. In the case of the many samples examined by him, the biological work was performed by expert biologists at the Johns Hopkins University, with most interesting results. Chas. Ekin, in his work on "Potable Water," claims, in regard to the various chemical method for the estimation of pollution of water by animal matter, that "all are absolutely worthless, so far as distinguishing between organic matter that is dangerous and organic matter that is innocuous is concerned," and that "the chemist has no special knowledge or experience beyond that pertaining to all intelligent educated men who take an interest in sanitary matters, to guide him in forming an opinion as to what may or may not be the conditions under which diseases may arise that are the outcome of unwholesome surroundings; and the sooner this is recognized and the matter relegated, in disputed cases, to those who alone are competent to give an authoritative opinion, viz: those, who, practicing medicine, have made hygiene a special study, so much the better will it be for the health of the community." This statement, it seems to me, detracts decidedly too much from the importance of the work of the chemist, for there is little doubt but that in the majority of cases chemical analysis throws strong light upon the question in hand.

Let us survey briefly the general method of procedure of the biologist.

A careful study of bacteria, their appearance, modes of growth, and behaviour under various conditions have given the bacteriologist the means of detecting the presence of various species. The problem becomes one of ascertaining the presence or absence of those productive of disease, and their approximate numbers. The number and varieties of species present in water from any given source depends upon conditions relating to the amount of organic pabulum present, the temperature, its pollution

from various sources, and other circumstances. Water that has come in contact with sewage containing the excrete of animals suffering from diseases, such as typhoid or scarlet fevers, is liable to contain the organisms which, when taken into the system, will produce these diseases. But organic matter, even sewage, may be present and harmful germs may be absent, and the water, from a sanitary point of view, may be without objection. The biologist is in position to say specifically, whether or not those particular germs are present which would vitiate the water. The examination is made about as follows:

A sample is collected with great care in a vessel that has been previously rendered free from bacteria, or "sterilized," by proper precautions. The analysis is made at once, since experience has shown, that on standing the bacteria increase wonderfully in numbers, and untrue conclusions would otherwise be reached. A definite quantity of the water, usually one cubic centimeter or less, is added to an infusion of beef peptone in gelatin or agargelatin in a test-tube, the whole having been previously sterilized, which is quickly stoppered loosely with sterilized cotton wool in order to prevent the entrance of bacteria from the air. The gelatine or other medium thus used is called "culture medium," and in it the little germs find nourishment, and in the course of a few days develop into so-called colonies, each germ giving rise to one colony. The numbers and nature of the colonies obtained from a known quantity of the water under investigation, furnish a means of estimating the number of germs originally present, and hence the probable effects of the water on the system. Sometimes the numbers are counted by causing the gelatine to flow over the inside of the tube as uniformly as possible, and then applying a microscope from without, counting the colonies contained in each square centimeter of area and adding the results (Esmarch).

Sometimes the development of the colonies is conducted in films of gelatine or sterilized glass plates, well protected from extraneous germs and divided into areas convenient for counting (Koch).

Conclusions have been reached by Sternberg and others that water containing less than 100 bacteria per cubic centimeter may

be regarded as safe for drinking purposes. Water containing more than 500 is suspicious, and probably contains organic matter from sewage which furnishers pabulum for the great increase in numbers of bacteria, among which injurious forms probably exist. The quantitative determination is comparatively easy. The qualitative examination is more difficult. In order to say definitely that certain specific bacteria are present the investigation must be carried much farther. As before stated, the appearance and characteristics of various bacilli are known, but, for their recognition, the colonies under investigation must be, to a certain extent, isolated. A so-called pure culture must be made. By means of a sterilized platinum wire a little of the suspected portion of the mixed colonies is taken out and a second tube is quickly inoculated. After a degree of maturity of development of the germs in the second tube has been reached a third is inoculated and so on, until the culture of the suspected germ has become sufficiently purified from the other bacteria for the expert to be able to identify it. The final proof of its presence is obtained by inoculating some living animal, for example a rabbit, by hypodermic injection of the product and noting its effects on the system. By this kind of work definite positive results are obtained. There is little room for exercise of personal judgment and calculation of chances. The results speak for themselves. The chemist obtains his analytical results, and then by exercise of judgment, forms an opinion as to whether the water in hand is or is not probably injurious to health. The bacteriologist is in position, by sufficiently painstaking work to say definitely whether or not certain specific germs of disease are present, and can in cases of suspected waters point out the particular dangers attending their use. The conclusions of the chemist are valuable and are not to be underrated, but the conclusions of the bacteriologist are more specific and involve less speculation in addition to results obtained by experiment. Bacteriological work is, however, not all-sufficient. As seen, chemical analysis falls short of telling all concerning sanitary properties of water. For a thorough investigation, the two lines of work should go hand in hand, supplementing one another.

Bacteriological examination of water is comparatively new—a matter of a dozen years' development. Its methods will undoubtedly be carried to greater perfection. Such work requires an expert but so does all valuable chemical work. It requires much time. But if results are of great importance they are worth expenditure of time and of expert work if these things are necessary to definite conclusions.

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THE BASIC BESSEMER PROCESS.

The successful application of the principle of that phosphorous can be removed from pig iron, in the process of refining by which it is changed into steel or malleable iron, provided that this process can be so carried on as to secure and maintain a basic slag, is of comparatively recent date. According to the metallurgical journals of the year 1877 the desirability of obtaining a method of applying Bessemer's process to phosphoritic pig iron was not questioned, although it was stated, that the prospects for attaining this end by means then known were not encouraging. In 1872 Snelus had discovered that the retention of phosphorous in the metal depended upon the condition of the slags, and that when these were of a more basic character the greater part of the phosphorous could be eliminated. These results of Snelus' experiments were not published until some time later, when Gilchrist and Thomas announced similar results. The obstacle in the way of obtaining such slags lay in the fact, that if the slags were made, or tended to become basic, they would react with fluxing effect on the acid, silicous, furnace linings, then universally in use; the linings would thus be destroyed and the slag at the same time rendered silicious to such a degree, as to drive all the phosphorous present into the iron. The first man to recommend the use of a non-silicious converter lining was Tunner, a German iron master. In March, 1888, Thomas obtained a patent for the use of a soluble alkaline silicate in the manufacture of material for a basic lining.

This lining was not durable, so in October, 1878, he obtained a second patent for the manufacture of a fire proof basic brick, composed of magnesia limestone with small quantities of silica, alumina and oxide of iron, forming the mass into bricks and burning these at a white heat—to be used as a lining. From the dates of these patents until the present time we may consider the Basic Bessemer Process to have been introduced and improved until its present degree of perfection has been obtained.

As is well known, in the ordinary or acid Bessemer process the pig iron should contain a minimum amount of phosphorus, as almost all of this element is retained in the resulting steel; and should the percentage of phosphorus exceed a very small amount, the metal would be rendered cold short. In the Basic Bessemer process, however, it is requisite that the pig iron should contain at least 2.5 per cent. to 3 per cent. of phosphorus, for the amount of heat developed during the after-blow is dependent upon the amount of phosphorus contained in the pig iron. Owing to the basic nature of the lining used, this element is caused to pass as a tri-basic calcium phosphate, and to some extent, as a tetra-basic calcium phosphate, into the slag.

In order better to understand the working of this process, we will begin with the raw ore and follow it through the succeeding steps until the finished product is obtained, as practiced at the Pottstown Iron Co.'s Works at Pottstown, Pa. The ores used are all high phosphuretted iron ores. The blast furnace charge is so calculated as to give a pig iron containing approximately:

Silicon,	0.5%	to	trace.
Sulphur,	0.02%	to	0.04%
Manganese,	0.8	to	——
Phosphorus,	2.5%	to	3.00%

The pigs of iron are broken into pieces one-fourth their original length and charged into the cupola with coke and scrap-iron. The molten pig-iron is tapped from the cupola into large ladles and transported on trucks to the converters. There are three of these vessels, two of ten tons and one of thirteen tons capacity. In constructing a converter, it is usual to calculate on the basis of 465 square inches sectional area per ton of iron. These converters are lined with a basic lining of about fifteen inches thick-

ness. The lining is prepared from raw stone by crushing thoroughly in a crushing machine, mixing, and dampening sufficiently so as to cause it to cohere under pressure. This is then pressed in a brick machine into bricks, which are carried to ovens where they are burned. During the process of burning they shrink to about one-half their original size. After they are removed from the oven and allowed to cool, they are ground up, or rather pulverized, and mixed with tar to the consistency of a mortar. In this state the material is rammed into the convertor around a wooden core. After the ramming is finished, the core is removed and a coke fire lighted to dry the lining. The convertor is then ready for use. The average life of a lining is about 150 heats.

In the case of an individual heat, 11.5 per cent. to 13. per cent. of lime is charged cold through lime chutes into the convertor, still hot from the previous heat. The effect of this lime is to neutralize any silicious matter in the charge. The length of the blow varies, the average being sixteen minutes; the fore-blow continuing eleven minutes and the after-blow five minutes. Scrap-iron can be added at any time through the lime chutes to regulate the temperature. Mr. Hartshorne, in his paper in the *Engineering and Mining Journal*, of November 5, 1892, states that if the slag be too thin, owing to any cause, it will attack the lining of the convertor and set up reactions which cause the phosphorus of the slag to pass back into the steel. The "change," or end of the fore-blow, is determined by means of a spectroscope; and the length of the after-blow depends upon the amount of air previously blown through the charge. As the vessel is turned down, 0.6 to 0.8 per cent. of ferromanganese is added. The "ferro" is 80 per cent. manganese. After two-thirds of the charge has been poured into the ladle, 1 to 1.5 per cent. of spiegeleisen is added and the pouring finished. The spiegeleisen is 10 per cent. Mn. The ladle is carried on a car to the casting-pit, where the metal is tapped into moulds arranged in a straight row. The casting is carried on very slowly. After the mould is filled up it is allowed to settle and more molten metal added. This is repeated until only twenty-five to fifty pounds can be added at one time, when a cast-iron cover is placed over

the metal. In this way it is possible to obtain a very sound casting. After the metal has taken the shape of the moulds, the ingots are "stripped,"—*i.e.*, the moulds removed—and transferred the soaking pit.

The soaking-pit, in the German patent termed equalizing-pit, was introduced by Gjers in 1882. It consists of a pit with fire-proof lining, in which one or more of the ingots, cooled sufficiently to harden the outside, but still molten in the interior, are placed, in order that the temperature may become uniform throughout the mass. Prior to the use of soaking-pits, the ingots were covered with sand or some other non-conductor of heat, and carried immediately to the rolling mill; but it was impossible to obtain a uniform heating. In the present practice some heat of the ingots is lost by giving it up to the walls of the pit, but the temperature of the ingot becomes thoroughly equalized.

In case the ingot adheres to the mould, it is placed in the "extractor" where it is pushed out by a hydraulic ram. From the soaking-pits the ingots are put through the rolls and shipped to their destination.

The iron manufactured is used for boiler, tank, and ship plate, iron and steel; nail plate; bridge and girder plate, iron and steel; steel billets, and slabs.

The basic bricks used in the manufacture of the lining showed the following composition:

Insoluble Residue, . .	1.192
Fe_2O_3 and Al_2O_3 . .	3.04
MgO	1.512
CaO	95.21

The slag produced, being high in phosphates, is a very valuable by-product. From the slag dump the slag is carried to the phosphate mill, where it is finely ground up in a ball mill. The ball mill, or ball machine, is very simple and ingenious in construction, and grinds, on an average, one ton per hour. Ninety-five to ninety-eight per cent. of this product is 100-mesh and 70 to 75 per cent. is 150-mesh. This is put in 200 pound bags and sold as a fertilizer. It runs from eighteen to twenty-four per cent. phosphoric acid, of which fourteen per cent. is reverted.

At one place in Europe steel is made as a by-product in the production of slag for fertilizer.

The following table represents a series of five heats, each producing four ingots, with the analysis of a sample of steel from each ingot:

Blow Number.	Ingot.	*C.*	*S.*	*P.*	*Mn.*
6997	1	.09	——	.040	.630
	2	.10	——	.030	.740
	3	.11	——	.040	.650
	4	.09	——	.035	.650
6998	1	.08	——	.035	.325
	2	.08	——	.030	.320
	3	.08	——	.030	.325
	4	.08	——	.040	.300
6999	1	.08	——	.045	.415
	2	.08	——	.035	.425
	3	.08	——	.050	.405
	4	.08	——	.035	.415
7000	1	.10	——	.035	.425
	2	.10	——	.050	.390
	3	.11	——	.055	.455
	4	.10	——	.055	.445
7001	1	.10	——	.030	.440
	2	.09	——	.050	.430
	3	.10	——	.050	.450
	4	.09	——	.050	.450

The above table shows the regularity of the steel of each heat. In no heat does the carbon vary more than .02 per cent., the the phosphorus .02, and the manganes .09.

In order to show the homogeneity of this steel, below are the analyses of eight samples from each of four ingots of one heat. After the ingot was rolled the first sample was taken two feet from the upper end, and the rest every four feet.

Ingot Number.	Sample.	*C.*	*S.*	*P.*	*Mn.*
1	1	.06	——	.020	.205
	2	.06	——	.020	.205
	3	.06	——	.020	.210
	4	.07	.030	.025	.215
	5	.06	——	.020	.220
	6	.06	——	.030	.220
	7	.07	——	.030	.230
	8	.06	——	.020	.195

Ingot Number.	Sample.	*C.*	*S.*	*P.*	*Mn.*
2	9	.06	——	.025	.205
	10	.05	——	.025	.210
	11	.05	——	.025	.210
	12	.07	.025	.025	.210
	13	.05	——	.030	.220
	14	.05	——	.020	.225
	15	.07	——	.030	.210
	16	.07	——	.020	.210
3	17	.06	——	.025	.205
	18	.07	——	.025	.210
	19	.06	——	.020	.205
	20	.07	.027	.025	.200
	21	.07	——	.020	.210
	22	.07	——	.020	.205
	23	.07	——	.025	.210
	24	.07	——	.020	.220
4	25	.07	——	.025	.190
	26	.07	——	.025	.175
	27	.06	——	.025	.175
	28	.07	.033	.020	.215
	29	.07	——	.020	.190
	30	.06	——	.015	.195
	31	.07	——	.025	.180
	32	.07	——	.025	.200

These tables of analyses were taken from Mr. Hartshorne's paper in the *Engineering and Mining Journal.*

FRANK S. LOEB, '93.

NOTES ON BASIC REFRACTORIES.

MAGNESITE.

The advantages obtained by using a basic sole in the open hearth furnace are gradually forcing themselves on the steel workers of the United States, and the result may be seen in the slow, though gradual, growth of the basic open hearth furnaces, and in the demands of the steel user for low phosphorous metal.

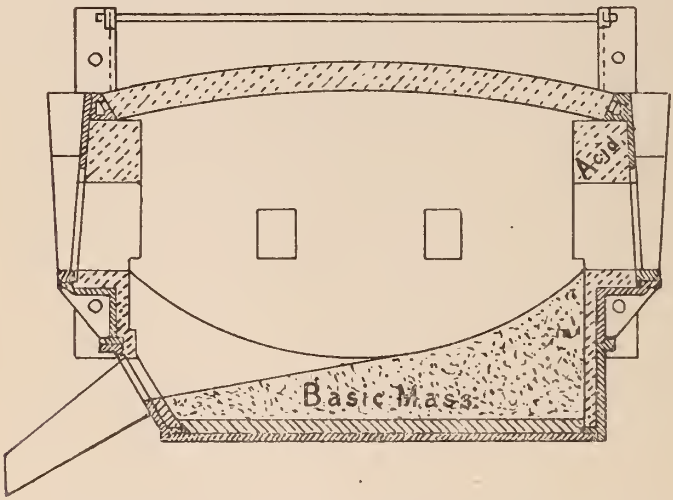
When the manufacturer's mind begins to turn basic-ward there are two questions that probably first demand his attention,—the one, how much cheaper will his metal mixture be, the other, where to obtain a suitable lining material. In this article, I propose to briefly treat of this latter point.

In the earlier days of the application of a basic sole to the open hearth, it was considered necessary to have not only a basic material for the bottom of the furnace, an acid material for the ports, sidewalls, and roof, but also a neutral material which could be used as a separator between the latter two, and so prevent them from mixing and slagging away.

The more modern practice has eliminated this neutral material by changing somewhat the design of the furnace, so that the side walls and roof are outside, supported as shown in the sketch. A more extended use of basic lining materials having also shown that when they are brought into contact with acid brick there is little or no slagging action, unless there is a pressure on the joint.

Of the materials most frequently used for basic linings, magnesite and dolomite are the best known. Magnesite has not as yet been found in merchantable quantities in this country, and our supply is imported from Greece and Styria. It can be purchased in the raw state for about $10 per ton in New York; calcined for about $15 to $20; and *dead-burnt* in the shape of bricks for from $175 to $200 per thousand. Such bricks when properly made are an extremely valuable refractory material. Having been burned often and hard enough, they do not shrink when exposed to high temperatures, are perfect in form and very dense in structure, wheighing about nine pounds apiece. It

should be noticed as one of the peculiar properties of magnesite that it is extremely slow to slake. Even after the stone has been subjected to one burning (it is then *calcined*,) when it has gone through the same treatment that makes lime of a dolomite or calcite, it will remain unchanged for many weeks in the open air. After it has gone through the three or four burnings that are required to make bricks of it (it is then *dead-burnt*), an exposure for an indefinite length of time seems to have no effect on it. It must be immersed in water for several days before any slaking action can be observed.



In its calcined form it is used in many European plants for furnace bottoms, the ports and occasionally the side walls being built of the bricks. Owing to its great cost, only one plant in this country has ever made a practice of using it for the bottom, and I am informed that they have recently discontinued so doing. In spite, however, of their great initial cost, the bricks can be advantageously used in the ports. If the roof, side walls, and ports of a furnace having a basic sole be made of acid brick, it will be found that the roof will be destroyed neither more rapidly nor more slowly than if the sole were acid, but that the side walls will be attacked somewhat more rapidly, and that the ports will be destroyed the most rapidly, lasting not more than

one-third as long as in an acid furnace. If the roof be high enough above the bath to insure a good working furnace, be it acid or basic, neither the splashes of the basic slag nor the basic dust arising from the lime and patching material will reach it.

By referring to the sketch it will be noticed that the side walls are set back from the bath, and will thus be similarly, though in a less degree, protected. Though the ports *may* be placed far enough away from the bath to ensure against any attack from splashes of slag, they cannot be protected from the fine dust which arises from the lime, the patching materials, and the surface of the bath, when it is boiling freely.

The effect of this is most plainly marked on acid ports, and though a life of 150 heats is almost universally claimed for such ports when used on a basic furnace, it is extremely doubtful if the average is over 125. I am unable to state exactly the life of ports made of magnesite bricks, but I am satisfied from my experience with ports still in use that they will last long enough to more than pay for their extra cost.

The magnesite that is sold as "calcined" has passed through but one burning, and on further heating will shrink very considerably. As there is, at the time when a furnace bottom is being patched, much spare heat this is not an objection to its use, since it will shrink and "set" in the holes of the bottom in about the same time that sand will on an acid bottom. There are many magnesite bottoms in successful operation on the continent, and the patching is done with the ordinary calcined material. My own experience with such a bottom has been very limited and very unsatisfactory. There was a decided tendency to a thick slag, which, I may here note, is one of the troubles of basic practice, and a decided increase in the amount of material required for patching and, of course, of the time required for that work.

DOLOMITE, CALCITE.

A dolomite suitable for open hearth use should, before calcination, contain not more than one per cent. SiO_2, and preferably less than one-half of one per cent. Such stone may be obtained in various parts of the country, though it is far from being abundant. If this stone were given but one burning at the ordinary

temperature, as with magnesite, lime would be produced. This is much softer than, and has not shrunk as much as, magnesite subjected to the same treatment, and for these reasons is not desirable for use as a lining or patching material. In order to fulfill in the best manner the duty required of it, the shrinkage must be carried to almost its greatest extent or until it becomes *dead-burnt*. In order to do this a special plant is required, since the stone cannot be so burnt in the ordinary lime-kiln.

The simplest and earliest method was to charge the stone and coke in alternate layers in a cupola. With the aid of blast sufficient heat was generated to burn the stone. This plan has the disadvantage that many pieces of the stone are not thoroughly burnt, and that the ash from the coke forms clinkers with the stone. The product is not uniform in hardness, is dirty, and must, therefore, be hand picked, adding considerably to the expense in order to free it from ash and clinkers. The Mendheim Ringofen may be used. In this case, of course, the product would be clean. A very simple form of oven or kiln is used at one plant in this country. A rectangular chamber, having the openings to the chimney through the bottom, and with fire places at each end, is partly filled with loosely piled stone. After about thirty-six hours of hard firing the stone is sufficiently burnt for use on the open hearth.

These processes give a dolomite that is more or less evenly burnt, but in each case amply so for open hearth work.

The method employed by the Pottstown Iron Company is as follows: the raw stone is ground in a Gates crusher, raised by an elevator to a sieve, the coarser being returned to the crusher and the finer going to a "chaser" pan. The material that comes through the bottom of this pan is again sieved, the finer going into storage bins from which it is drawn in certain, measured quantities on to the floor, mixed by hand with a small proportion of basic converter slag, and shoveled into a horizontal dry mixer. As it is delivered from this mixer it is slightly moistened with water, and travels through a similarly constructed machine called the wet mixer. An elevator then delivers it into the hopper of a Whittaker brick machine. The bricks when formed are piled in kilns thirty feet long, five feet nine inches high, and

nine feet ten and one-half inches wide, with four fire places, two at each end. The doors of the kiln being bricked up, the fires are started, and as intense a heat as possible is maintained for from twenty-six to thirty-two hours. The fires are then drawn, and the kiln and its contents allowed to slowly cool off. The bricks thus produced are again ground up, mixed with tar, and rammed around a former or pattern in the converter to make the lining. If this material is to be used on the open hearth, the tar is omitted and the ground brick is thrown on the holes of the basic bottom in the same manner as a sand bottom is prepared. If the banks of the furnace are very steep, and it is found difficult to make the dolomite stick, the addition of a little tar will be found advantageous. Under ordinary circumstances, however, it is of no benefit, and, since it fills the furnace with a dense smoke, often a positive drawback, insomuch as the patching is delayed until the fumes clear away.

This method of making dead-burnt dolomite gives a remarkably uniform and clean product. The stone, before being burnt, may be said to be mixed four times—in the crusher, in the pan, on the mixing floor, and in the two horizontal mixers. The grinding, after it is dead-burnt, further tends to increase this uniformity. Such material is preëminently fitted for lining Bessemer converters, and while it is very valuable for open hearth work, it may be said to be too good for that purpose, since material not so clean, not so uniform, and not so well shrunken will answer fully as well. The difference in cost between the two would probably not be so great if the tonnage of product were large enough. The amount of basic material required for patching the bottom ranges between 100 and 200 pounds per ton of ingots made. Taking the average at 150 pounds, a single 20-ton furnace making a heat every twelve hours, would require 3000 pounds of dolomite per day. Running one cupola to supply such a furnace would, of course, be an expensive operation, and it is probable that it would not pay unless the steel plant consisted of at least four furnaces. In order to make dead-burnt dolomite economically by the "brick making" process, a product of at least 300 tons per month, or say twelve tons per day must be attained, hence the steel plant must consist of at

least eight or ten furnaces. If the stone be burnt by either of the processes for a less number of furnaces than noted, the cost will be considerably increased, and would probably almost reach that at which calcined magnesite can be bought.

In every case where I have used the word dolomite, calcite may be substituted, since in preparing it for use as a basic refractory material it must go through the same treatment as is given to dolomite. Its behavior is similar to dolomite in all respects, and the results from its use in every way just as good. The difficulty and expense of preparing dead-burnt material for basic open hearth work have undoubtedly prevented many owners of small plants from using this process. This trouble has been overcome in England by the establishment of several companies that burn the stone at the quarries and ship it to the various Bessemer and open hearth works. One, at least, of these companies was formed through the coöperation of several open hearth steel makers, no single one of whom would have been warranted in erecting a plant for burning the stone solely for his own use. J. S. ROBESON.

SOCIETIES.

TAU BETA PI.

On March 17th, the following members of the Class of '94 were received into Tau Beta Pi: Aubrey Weymouth, Weldon B. Wooden, William A. Allgaier, M. Harry Holz, Thomas W. Wilson, William McC. Hall, Rezeau B. Brown, William A. Payne. The initiation supper, at the Wyandotte Hotel, with its accompaniment of speechmaking and good-fellowship, was an enjoyable and commendable addition to the usual exercises of the occasion.

THE ENGINEERING SOCIETY.

At the February meeting of the Engineering Society, the formal papers were an interesting report by Mr. Sage, chairman of the Electrical committee, and a paper describing the great Forth Bridge by Mr. Blickle.

At the meeting held in the Chemical Laboratory, March 23d, Mr. Seibert delivered a very interesting and instructive lecture on the Geodetic and Coast Survey, illustrated by stereopticon views, sent out by the United States Coast Survey. The lecture was open to the public, and in spite of the bad weather the lecture room was well filled.

An amendment to the by-laws was adopted, at the same meeting, providing for a committee of investigation for the purpose of conducting scientific investigations under the directions of the Society.

An effort is being made to obtain a room, in Christmas Hall or elsewhere, for the use of the Society.

ELECTRICAL ENGINEERING SOCIETY.

The Electrical Engineering Society has at last began to meet regularly, and we are glad to note the interest already manifested in the papers read at each meeting. The first of this year was held in the Physical Laboratory, March 3rd. Mr. H .J. Atticks, '93, president of the Society, called the meeting to order at 7:30 o'clock. It was decided to hold meetings thereafter every two weeks, on Wednesday nights. at 7:30 o'clock.

Mr. Sage, '93, then read an interesting and well illustrated paper on "Water Wheels," and explained several methods of automatic speed regulation, used when driving dynamos. Mr. Grissinger, '94, followed with a paper on "Telephone Transmitters and Receivers." He has devoted much time and study to telephony, and was well capable of giving an interesting paper —which he did.

The next meeting was called to order by the president, in the Physical Laboratory, on night of March 22d. The two papers read were by Messrs. Van Cleve, '93, and Henshaw, '94. Mr. Van Cleve's paper was on "Secondary Cells," and treated in a comprehensive manner the construction and peculiarities of most of the prominent batteries used in practice, explaining the several functions of the sulphate and peroxide formations. Mr. Henshaw then discussed the "Present Situation of Incandescent Lamp Interests," giving an historical sketch of the incandescent lamp and describing the new "Westinghouse Lamp," that has recently

been placed upon the market and promises so many things. Both papers were followed by short discussions.

From the tenor of the papers read thus far, we see no reason why the Electrical Engineering Society should not continue to to prosper, and inspire even more interest than it now does.

ANNOUNCEMENT.

The time is approaching for the selection of a new QUARTERLY Board for the college year 1893–94. In order that the elections may be based on the proved ability and interest of the candidates, the present Board has adopted the plan of having a competition for these positions. This competition is to consist of the preparation of essays or papers on certain assigned subjects under the following

RULES.

1. The competition shall be open to all Juniors, except editors of the *Burr*. As far as may seem expedient, it is desirable to have one man from each of the six principal departments of the University,—viz., the Schools of General Literature, Civil, Mechanical, Mining, and Electrical Engineering, and Analytical Chemistry. In no case will more than two, of the six men to be chosen, be taken from the same department.

2. The subjects for these papers will be assigned by the Board, and the choice of subject will be limited to those thus assigned.

3. The length of the papers is left to the discretion of the writers, but a minimum limit of 800 words and a maximum of 3500 are recommended, the latter especially.

4. The papers are to be mailed to the Editor-in-Chief of the QUARTERLY on or before May 15, 1893. They are to be signed with a fictitious name or initials, and the course (of study) of the writer is also to be noted with this signature; and they are to be accompanied by a sealed envelope bearing on its exterior the same anonymous designation, and containing a statement, signed with the correct name of the writer, declaring that the accompanying paper is his own, unaided work.

The papers will be read and judgment pronounced on them before the sealed envelopes are opened. The elections will be based on this judgment, modified to a certain degree by knowledge of the personal characteristics of the writer. Realizing that other things besides the ability to write are requisite in the successful editor, the Board reserves to itself a certain latitude of choice; but the writers from any one department will be, in any case, preferred candidates for the position of representative of that department.

The object of this test is two-fold. *First*, to find out who have, and can demonstrate, the necessary literary ability; *second*, to secure as our successors men who have shown their interest in the QUARTERLY and their willingness to work for it by the effort which the preparation of such papers will require. This plan is an experiment, which we look to the Junior Class to make successful.

The following subjects have been selected:

College Honor in Examinations (with special reference to the Princeton scheme).

The Position of Modern Languages in a Technical Education.

Modern Methods of Topographical Surveying.

Bridges over the Lehigh before 1850.

Slag Bricks.

Methods of Producing Sound Steel Castings.

Self-Lubricating Materials for Bearings.

Methods of Reproducing and Duplicating Drawings.

Status of the Problem of Directly Converting the Heat of Coal into Electricity.

Electricity as a Transmittiug Medium.

Ventilation as Applied to Future Deep Mining in the Anthracite Regions.

Review of the Present Condition of the Glacial Theory.

Discussion of the Relations of Alchemy and Chemistry.

The Determination of Phosphorus in Pig Iron by Titration.

The treatment of these subjects may be descriptive; may consist in the discussion of vexed questions; may sum up the result of reading to determine the status of the process or theory; may be historical. We desire papers that would be worthy of being

read before the engineering societies, but rather more carefully prepared (as to literary composition) than the average paper of that class. Finally, as we hope to publish a number of these essays, we request that the usual rule,—write on one side only of the paper—be followed.

EDITORIAL.

THE Tau Beta Pi Society, whose history occupies the place of honor in this number of the QUARTERLY, is a Lehigh institution which has grown into a permanent place in the life of the University; but its work is so quiet and unostentatious that to many of our readers it has been little more than an empty name. None is fitter to tell of the history and purposes of this organization than Professor Williams, who was prime mover in its formation. The benefits which the society aims to confer upon those who prove themselves worthy to become members he clearly outlines.

Against such a classification of college men as Tau Beta Pi makes, it may be urged—and not without some show of justice—that high stand in one's class is not a sure test of capability; that the man who devotes a great deal of his time to athletics, to literary work, or to some other form of activity outside of his studies, putting only the minimum amount of work upon the latter, may be not less capable and less likely to succeed in after life than the steady and persistent "grind." Doubtless there are many cases where this holds true. But when we apply to college life the same criterions that business and professional life is judged by; when we remember that in college, as out of it, strict attention to duty and persevering industry are what lead to success; and that for securing high rank not only hard work but a considerable amount of natural ability is needful; when we take account of all these things, it seems a not unreasonable application of the law of probabilities to conclude, that the honor of wearing the badge

of Tau Beta Pi is not only a reward for meritorious attainment in college, but a good augury for the success of the wearer in the work of his profession.

The description of some recent discoveries in the archæological line, rendered from the German by Mr. Fichter, of Bethlehem—who, as a native of the Father of Republics, is naturally interested in the researches into the life of pre-historic man so successfully carried on by his countrymen—is an interesting diversion from the usual class of subjects treated in our pages. We have in the settlement whose remains have been so carefully dug up the rather curious anomaly of cave dwellers who did not dwell in a cave, but under the open sky. The topography of the spot, with its sheltering cliffs, accounts for their choice. This article is especially *apropos* for those who have been attending Dr. Worcester's Bible class; the outline of the general subject which he has given will enable them to read this more detailed account of a particular case with understanding and appreciation.

Prof. Merriman, in his suggestion as to the use of the Library, touches upon an important topic. It is probable that of those students who spend some part of each day in the Library, not more than one-third go there to read—the use of the building as a study and waiting-room between recitations accounts, however, for this. But the worst of it is, that of those who do read, nine-tenths spend their time in a mere cursory glance over the current periodicals, and only a paltry few are engaged in real systematic reading or study. After a brief setting forth of the advantages of systematic general reading, Prof. Merriman devotes the bulk of his article to giving useful hints and directions to those who wish to pursue special lines of research on topics of science and engineering, telling them where to look for the guides, who will lead them through the great maze of technical periodical literature to the treasures of information for which they are seeking. The paper is eminently practical, and, evidencing as it does a large experience in such work, will be of permanent value to all who expect to spend much time in delving among books for knowledge.

In the second part of his Notes on Rope Driving, Prof. Flather goes into the details of the design of a rope drive; he describes

the methods of avoiding the evil effects of differential driving effect, discusses durability and proper working stresses in ropes, gives the usual practice as to size of rope used, and deduces complete formulæ for the horse power transmitted. Now that the subject has been completed, the value of this contribution to the pages of the QUARTERLY becomes fully evident, and we feel sure that it will be a useful addition to the knowledge of many of our readers.

The account of the Port Royal Dry Dock, which, so far as we know, has not been as yet described in any unofficial publication, comes from an Alumnus who, as assistant engineer in charge of the work, knows whereof he writes. Mr. Diebitsch has described, chiefly, the structural features of the work, and has written in a popular style, which will make his paper interesting not only to civil engineers but to all others.

The paper on sanitary water analysis by Prof. Dashiell, a former instructor in Organic Chemistry, while in its description of methods it appeals chiefly to the chemist, is of interest to all, for every man is interested in the question of pure water supply. The writer describes the several chemical methods, gauging their value, and compares them with the more recent, more accurate, but more time consuming bacteriological tests for dangerous impurities in water, and draws conclusions as to their relative positions in practical work.

The basic processes for making steel and iron from ores high in phosphorus has been attracting a great deal of attention from metallurgists all over the world for some years. Mr. Loeb's description of basic Bessemer steel making, as conducted in one of the two successful mills of the kind in this country, gives a complete outline of this branch of the subject, which will be of interest to our general readers, though it may not contain much that is novel to those who have made a special study of the modern metallurgy of iron. To those who are more concerned with the specialties of the subject, the paper by Mr. Robeson, superintendent of the same plant — the Pottstown Steel Works— on basic furnace and converter linings will appeal more forcibly. Current practice as to composition, preparation, and placing of these lining materials is clearly set forth in concise terms.

THE Engineering Society is trying to secure a room in Christmas Hall where it can keep its possessions — models, drawings, books, etc. — a combined library and museum. This attempt to establish a regular headquarters for one of our organizations, leads us to say something about a suggestion which appeared in the *Burr* of March 4; a suggestion which is, we think, the very best that has yet been made with regard to the memorial which the Alumni Association is so anxious to erect to our founder. What we *need* more than anything else is a building where our various societies can hold their meetings, and have rooms of their own in which to hold committee and other small meetings, and keep their archives.

The Engineering Society might, in a few years, accumulate a valuable collection of models, papers prepared by members, pamphlets, drawings, photographs, etc., if only it had a place in which to preserve them and make them accessible for reference. The special engineering and scientific societies do have, at present, a certain degree of accommodation as to meeting places in the buildings of their several department. But they would be better off if brought into closer contact with each other, and thus stimulated to a friendly rivalry. College debating societies, interest in which has been recently aroused to an unusual degree, have no place suitable for holding their meeting. The Y. M. C. A. hopes to have a building of its own some day. But this day must be a good many years in the future; and the construction of a separate building for this one organization would involve a dispersion of energy which had better be concentrated in such a scheme as has been suggested to us—"Alumni Hall."

We have in mind a building with one large auditorium, capable of seating three or four hundred; connecting with it several smaller rooms, of fifty to a hundred capacity, which could, on special occasions, be thrown open to the main hall, and which would be used for the regular meetings of the Y. M. C. A., Bible Class, Technical Societies, Literary Societies, Musical Organizations, etc.; a number of smaller rooms to be used as headquarters by the individual organizations, to which their officers could have access at all reasonable hours, and where their possessions and records could be kept and handed down intact from year to

year. A reading room, such as many colleges possess, where the current periodicals can be looked over without the tedious formality of library checks, would be a most welcome addition to our college facilities.

We all realize the lack of that unity in college life which the centralizing influence of the dormitory system tends to develop. Dormitories we see no prospect of, nor are we sure that they are greatly to be desired. But such a college headquarters as a building like this—placed on the most accessible part of the Campus, and not at the very top of the hill where the present make-shift, the Gymnasium, is situated—such a common center would do much towards bringing about that contact between man and man, and class and class, away from daily work, which is so much needed.

A bronze statue would be a beautiful memorial; a larger observatory would, doubtless, greatly facilitate astronomical work and observations; an hydraulic laboratory is needed, to a certain degree; but from the standpoint of the greatest good to the greatest number, and as a supplement to the munificent gifts of Asa Packer, nothing would accomplish so much, nothing testify so loudly to the gratitude and loyalty of those who in the past have enjoyed the fruits of his benefactions, as such an addition to the noble structures which crown our campus.

THE QUARTERLY goes to press with final action on the "beer question" still pending; but even though the matter will probably have been settled by the time this reaches our readers, we can not forbear an expression of opinion. The custom, in accordance with which the Freshmen used to supply to the Sophomores free and unlimited beer on Cremation night, was first voted down in '93, strong efforts to the same end having been unsuccessfully made in several previous classes. Attempts to revive it were met, in '94 and '95, by largely increasing majorities. By what seems to have been a rather hasty action of the Freshman Class, in a class meeting where one side was much more fully aware than the other that the question was to be brought up, it was voted to revive this custom. Criticism of the method of making this decision is superfluous, however, as the question

has since been re-opened and is to be decided by a poll ballot, in which each voter will be given an opportunity to register his opinion.

As to the "custom" itself—though why it should be called a custom after having been rejected by the upper classes we do not see—it is a subject which it is extremely difficult for a strong advocate of either side to view from the standpoint of his opponent; so that common premises for an argument are somewhat hard to find. But laying aside all questions as to the consumption of beer by individuals and in not excessive quantities, all, or nearly all, will agree that for a crowd of men—any kind of men, but especially collegians—to get together around a couple of beer kegs, with all the enthusiasm which comes with numbers and with every restraint thrown off; for such a crowd to get together and indulge in the wild orgies that have characterized this celebration in the past, is neither an act worthy of educated gentlemen, nor a credit to an institution of higher learning.

It is futile to say that if the men want beer they will get it anyhow—therefore give it to them. It is true that small parties may go to saloons after the cremation ceremonies, and there indulge in liquid refreshments; but they are likely to be the habitues, who "have been there before" and who "can stand it." But suppose all these parties coalesced into a crowd, and with them many who only want to see the fun, or who have a half desire to be "a little tough." Add the strong influence of example and of numbers and—well, we would not care to bear the responsibility for what is likely to follow.

The decision of the Freshmen Class, if persisted in, is a distinct step backward, a renewal of a blot which had been wiped from Lehigh's escutcheon. It is against the sentiment not only of the other class immediately concerned—the Sophomores—but also of the upper classes; not only of the radical temperance men, but of the great number who, while they do not take a strong personal stand in this matter, are opposed to having a grand "college drunk" with the stamp of organized approval upon it. We echo the opinion of the great majority of the students, outside of the Freshmen Class, when we say, that if '96 really desires to contribute to the events of Commencement Week, it could certainly

have found something more creditable to itself and to the University than the attempted revival of the worst custom Lehigh ever had.

CRITICISM is a good and beneficial thing if given and received in the right spirit; we know this and we are always glad to hear what our esteemed contemporary the *Burr* has to say about us. But in the review of our last number there was a little criticism with which we do not agree. The critic objects to our having an editorial on the athletic situation, on the ground that since the QUARTERLY is an Engineering Magazine, it ought not to concern itself with the affairs of ordinary college life, but devote its entire attention to scientific discussions; and then, rather inconsistently, he reproaches us for having abandoned the departments of "Waifs and Strays" and "Original and Good;" departments in which, if the critic will review them, he will find athletics and other college subjects treated of; but departments literary in nature, which, in the trend of the QUARTERLY towards the character of a publication almost entirely devoted to technology, have been very consistently dropped. In our editorial columns we feel just as much at liberty to discuss questions affecting the welfare of our Alma Mater as does the *Burr*, though of course, with our less frequent issue, we have to limit our attention to matters of the least transient interest.

FOR LEHIGH MEN.

This column will contain, chiefly, such information in regard to addresses and occupations of Alumni as does not appear in the latest issue of the *Lehigh Register*. Please contribute.

'77. L. T. Wolle, C.E., Cambria Mining Co., Cambria, Wy.

'79. F. W. Sargent, C.E., Gen. Agt. of Sargent Co., Iron and Steel Founders, 49th and Wallace St., Chicago, Ill.

'85. T. W. Birney, C.E., 420 5th St., N. W., Washington, D. C.

'85. W. N. Edson, C.E., Superintendent of Bridges and Construction Department, Pennsylvania Steel Co., Steelton, Pa.

'86. J. H. Brown, C.E., 164 Dearborn Ave., Chicago, Ill.

'87. H. S. Meily, C.E., Huntingdon, Pa.

'88. J. J. Clarke, M.E., *Colliery Engineer*, Scranton, Pa.

'89. J. W. Dougherty, B.S., Superintendent of Blast Furnaces, Pa. Steel Co., Steelton, Pa.

'91. F. C. Lauderburn, B.A., with *Newark Advertiser*.

'91. A. Eavenson, A.C., Asst. Chemist, P. & R. R. R., 419 Franklin Street, Reading, Pa.

'91. E. H. Coxe, C.E., Asst. Engineer, Columbus & Hocking Valley Coal and Iron Co., Buchtet, O.

'92. W. L. Jacoby, M.E., Latrobe Steel Works, Latrobe, Pa.

'92. C. T. Mosman, E.E., Lynn, Mass., with Thomson & Houston Electric Co.

'92. A. Schneider, C.E., with Union Pacific R. R., care J. C. Melvery, Ogden, Utah.

'91. H. Ichikawa, A.C., care Imperial Printing Bureau, Tokio, Japan.

As an example of how a man's reputation may travel without his knowing it: Prof. Merriman has recently received a copy of a little *Journal de Sciencias Mathematicas e Astronomicas*, published in Coimbra, Portugal, in which is reviewed a translation of his book on The Method of Least Squares. This translation was made by a Professor Balbin of the University of Beunos Ayres, for the use of students in that institution; it was published in 1889, and reviewed in this Portuguese journal the same year. And now, four years after, the first knowledge of the translation comes to the author of the work.

Lehigh, it has finally been decided, is to have an exhibit at the World's Fair. It will consist of outlines of the courses, numerous drawings, pictures of buildings, and of drawing rooms and laboratories, pictures of the various athletic teams, copies of the several publications, and any examples of students' work in the way of apparatus which may be of sufficient merit. Hard work is being put on the preparation of the exhibit.

PERIODICAL AND BOOK NOTES.

KEY TO ABBREVIATIONS OF NAMES OF PERIODICALS.

TITLES.	WHERE PUBLISHED.	ABBREVIATIONS.
Abstract of the Proceedings of the Chemical Society.	London.	Ab. Proc. Chem. Soc.
American Architect.	Boston.	Am. Arch.
American Chemical Journal.	Baltimore.	Am. Chem. Jour.
American Engineer and Railroad Journal.	New York.	Am. Eng. R. R. Jour.
American Journal of Mathematics.	Baltimore.	Am. Jour. Math.
American Journal of Science.	New Haven, Ct.	Am. Jour. Sci.
American Machinist.	New York.	Am. Mach.
American Manufacturer and Iron World.	Pittsburg.	Am. Man. and I. W.
Analyst.	London.	Anal.
Annales de Chimie et de Physique.	Paris.	An. Chi. et Ph.
Annals of Mathematics.	Charlottesville, Va.	Annals of Math.
Anthony's Photographic Bulletin.	New York.	Anth. Phot. Bul.
Astronomical Journal.	Boston.	Ast. Jour.
Bulletin de la Société Chimique de Paris.	Paris.	Bull. Soc. Chi.
Berichte der Deutschen Chemischen Gesellshaft.	Berlin.	Ber.
Bulletin of Iron and Steel Association.	Philadelphia.	Bull. I. and S. Ass.
Chemical News.	London.	Chem. News.
Colliery Engineer.	Scranton, Pa.	Coll. Eng.
Electrical World.	New York.	Elec. World.
Electrician.	London.	Elec.
Engineering.	London.	Eng.
Engineering and Building Record.	New York.	Eng. Build. Rec.
Engineering and Mining Journal.	New York.	Eng. Min. Jour.
Engineering News.	New York.	Eng. News.
Iron.	London.	Iron.
Iron Age.	New York.	I. Age.
Journal de Pharmacie de Chimie.	Paris.	Jour. Ph. et Ch.
Journal für Praktische Chimie.	Leipzig.	Jour. für Prak. Ch.
Journal of Analytical and Applied Chemistry.	Easton, Pa.	Jour. An. Ap. Chem.
Journal of Gas Lighting.	London.	Jour. Gas Light.
Journal of the Association of Engineering Societies.	Chicago.	Jour. Ass. Eng. Soc.
Journal of the Chemical Society.	London.	Jour. Chem. Soc.
Journal of the Franklin Institute.	Philadelphia.	Jour. Frank. Inst.
Journal of the Royal Microscopical Society.	London.	Jour. Roy. Micro. Soc.

Journal of the Society of Arts.	London.	Jour. Soc. Arts.
Journal of the Society of Chemical Industry.	London.	Jour. Soc. Chem. Ind.
Lancet.	London.	Lancet.
Lehigh Quarterly.	South Bethlehem, Pa.	Lehigh Quar.
Leibig's Annalen der Chimie.	Leipzig.	Leibig's An.
London, Edinburgh, and Dublin Philosophical Magazine.	London.	L. E. & D. Phil. Mag.
National Car and Locomotive Builder.	New York.	Nat. Car. Loc. Build.
Photographic Times.	New York.	Phot. Times.
Popular Science Monthly.	New York.	Pop. Sci. Mo.
Proceedings of the Engineers' Club of Philadelphia.	Philadelphia.	Proc. Eng. C. Phila.
Proceedings of the Royal Geographical Society.	London.	Proc. Roy. Geog. Soc.
Proceedings of the Royal Society.	London.	Proc. Roy. Soc.
Quarterly Review.	London.	Quar. Rev.
Railroad and Engineering Journal.	New York.	R. R. & Eng. Jour.
Railroad Gazette.	New York.	R. R. Gaz.
Science.	New York.	Science.
Scientific American.	New York.	Sci. Am.
Scientific American Supplement.	New York.	Sci. Am. Sup.
Scribner's Monthly Magazine.	New York.	Scribner's.
Transactions of the American Society of Civil Engineers.	New York.	Tr. Am. Civ. Eng.
Transactions of the American Society of Mechanical Engineers.	New York.	A. S. M. E.
Transactions of the Federated Institution of Mining Engineers.	London.	Tr. Fed. Min. Eng.
Westminster Review.	London.	West. Rev.

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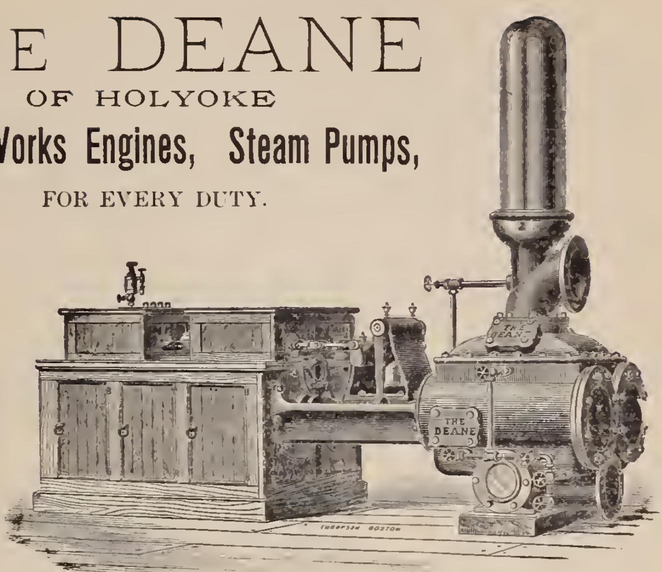

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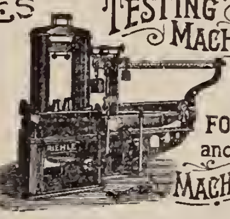

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